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MISCELLANEOUS.

## ERRATA.

Page 70, line 18, for "*Zwalenburg*" read "*Zwaluwenburg*"
,, 104, note, for "*rhinocetos*" read "*rhinoceros*"
,, 161, line 28, for "Rec. Ind. Mus., iv" read "Rec. Ind. Mus., vi"
,, 246, note, for "Bull. Ent. Research iii" read "Bull. Ent. Research viii
,, 301, note, 8th line, for "Manchester" read "Cambridge"

IMPERIAL BUREAU OF ENTOMOLOGY.

# BULLETIN
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# ENTOMOLOGICAL RESEARCH.

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## SOME PROBLEMS OF THE BREEDING-PLACES OF THE ANOPHELINES OF MALAYA: A CONTRIBUTION TOWARDS THEIR SOLUTION.

By W. A. LAMBORN,

*Malaria Bureau, Federated Malay States.*

Knowledge of the breeding habits of the Anopheline mosquitos has advanced greatly since the days when it was considered that the larvae of any species were distributed indiscriminately in all and sundry collections of stagnant water. In the Federated Malay States entomological research, which has now extended over many years, tends to show that preferences by the various species for different kinds of breeding-places exist; and attempts have been made to define in relation to particular species, or groups of species, the types of breeding-place favoured.

Thus in 1904 Dr. G. F. Leicester,* who investigated the breeding habits of Anophelines at Klang, classified according to breeding habit those he found, as follows:—

" (*a*) in mud-holes, *i.e.*, small holes made by the foot of a heavy animal or a waggon rut in a road: *Myzomyia rossii* [=*A. vagus*], *Cellia kochii*;

(*b*) in stagnant shallow water supplied by rain and liable to dry up: *C. kochii*;

(*c*) in swamp: *M. barbirostris*, *M. sinensis* [=*A. hyrcanus*], *M. umbrosus*, *C. kochii*;†

(*d*) in marshy ground fed by a stream: *C. kochii*, *Nyssorhynchus nivipes* [=*A. fuliginosus*]."

In 1908 Dr. C. W. Daniels,‡ in a general paper on the breeding habits of Culicidae, described the larvae of *A. aitkeni* (*treacheri*) and *A. maculatus* (*willmori*) as occurring in rapid streams; *A. rossi* as breeding in water much fouled with mud or fine silt; and *A. barbirostris*, *A. aconitus* (*albirostris*) and *A. kochi* as breeding in open country.

Dr. Malcolm Watson, discussing in 1911 the breeding-places of Anophelines, made numerous observations bearing on the distribution of Anopheline larvae.§ He pointed out (p. 116) that " *N. willmori* appears to prefer running water. There may be weeds but they must not too seriously interfere with the free current of water.

* "The Culicidae of Malaya," Studies from the Institute of Medical Research, Kuala Lampur, iii, pt. 3, p. 10, 1908.

† Throughout this paper the new nomenclature for certain species has been followed, the species formerly termed *A. rossi* var. *indefinitus* being called *A. vagus*; the Malayan form of *A. rossi*, Giles, becomes *A. subpictus* var. *malayensis*; and *A. sinensis* becomes *A. hyrcanus*.

‡ "The Breeding Habits of Culicidae," Studies from the Institute of Medical Research, Kuala Lampur, iii, pt. 3, p. 3, 1908.

§ The Prevention of Malaria in the F.M.S., 1911.

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*M. rossii* is at the opposite end of the scale from *N. willmori* and is a puddle breeder." Elsewhere (p. 111) in the same book he describes the situations in which he obtained Anopheline larvae in the Bukit Gantang valley - enormous numbers of *A. barbirostris* and *A. hyrcanus* (*sinensis*) in the paddi fields, *A. subpictus* var. *malayensis* (*rossii*) in pools near to the houses and *A. aconitus* (*albirostris*) in a stream running through paddi fields and in swampy grass through which water was flowing slowly.

Mr. C. Strickland * endeavoured, after a five years' study of the question, to define what is a typical breeding-place of a certain species by tabulating certain characteristics of the surroundings in which it was found ; but as Dr. Hacker has pointed out,† " the attempt showed the impossibility of doing this, owing to the very large number of not accurately measurable characteristics that have to be classified." Dr. Hacker nevertheless continued the same line of investigation in the hope of establishing a definite association between certain species and a definitely recognisable type of breeding-place, and basing his conclusions on an examination in the course of three years of no fewer than 4,949 breeding-places and the identification of 39,605 specimens, suggested‡ that the species may be grouped in the following manner :—

" Group 1, depending on a common preference for small open pools or open hilly country : *A. kochi*, *A. vagus*, *A. maculatus*, *A. karwari*, and *A. ludlowi*. The last of these species may separate itself from this group as the chief member of a salt-water fauna when further data have been collected.

" Group 2, depending on a preference for large swampy pools or low-lying country : *A. barbirostris*, *A. hyrcanus*, *A. aconitus*, *A. fuliginosus*, *A. subpictus* var. *malayensis*, *A. separatus*, *A. tessellatus*, *A. umbrosus*, and probably *A. aurirostris*. The last three may separate themselves later into a jungle swamp fauna, leaving the rest of the group as an open swamp fauna.

" Group 3, depending on a preference for jungle, probably hilly jungle : *A. aitkeni*, *A. leucosphyrus*, *A. albotaeniatus* var. *montanus* and *A. novumbrosus*.

" Group 4, species with highly specialised breeding-places : *A. asiaticus*."

He, however, weakens the validity of his conclusions by himself pointing out (p. 24) " that the groups are not sharply delimited shows that the species are not strictly limited in their choice of breeding-place but have a certain amount of adaptability." Elsewhere (p. 7) Dr. Hacker states that he, also, has found it " quite impossible to classify the characteristics of breeding-places so as to constitute a description of the typical breeding-place of each species." The latitude as to breeding habits is indeed brought out in his own " Association Value Tables " put forward in the same paper, *e.g.* (p. 14) he finds in 544 collections an association of *A. kochi* (group 1) with *A. hyrcanus* 78 times and with *A. barbirostris* 30 times (these two species being placed by him in group 2) : an association in 816 collections of *A. vagus* (group 1) with *A. hyrcanus* 84 times and with *A. barbirostris* 64 times.

Although the experience gained from the work of one year hardly entitles the writer to express an authoritative opinion, it may be said summarily that the result of his own investigations has been to enforce Dr. Hacker's qualification at the expense of his main thesis. In the face of the mass of data accumulated and presented below it is difficult to accept as of any great value the suggestion that the open country Anophelines (which are all comprised within groups 1 and 2) prefer for breeding either " open hilly country " or " low-lying country " ; for the larvae of all species at all common were obtained at the same level and in great abundance round Kuala Lampur, and though some of the species certainly seem to exhibit preference either for " small open pools " or for " large swampy pools," exceptions are quite numerous.

For the purpose of the present paper some actual examples of the exceptions which came within the experience of the writer may be recorded. *A. vagus* comes

* Unpublished report at Malaria Bureau.

† F.M.S. Malaria Bureau Annual Report for 1918.

‡ F.M.S. Malaria Bureau Reports, ii, 1920.

within the group of Anophelines which are said to have a preference for breeding in small open pools or open hilly country. But a collection of larvae from the bottom of an old boat, which contained a mixture of rain-water and water that had leaked into it from a fishpond on which it floated, afforded 162 larvae of this species in pure culture; and a collection, made at the same time from the fishpond itself, yielded 35 larvae of *A. vagus* also, 132 larvae of *A. hyrcanus*, 36 of *A. barbirostris*, 6 of *A. fuliginosus* and one of *A. aconitus*.

A collection on 1st December 1920 from small muddy pools afforded 368 larvae of *A. vagus* with 2 of *A. kochi*, 62 of *A. hyrcanus* and 28 of *A. barbirostris*, the two latter species being usually found in large swampy pools or low-lying country. In another collection, made on 15th April 1920 from small muddy pools in the same locality, 30 larvae of *A. barbirostris*, 4 of *A. hyrcanus* and 3 only of *A. vagus* were obtained. An answer to the speculation as to whether in a period of drought *A. vagus* ceased to breed, owing to an absence of its favoured breeding-places, small muddy pools, or availed itself of other waters, was provided by a collection made at such a season, in a fishpond. Here were secured, on 29th March 1920, 244 larvae of *A. vagus* with 53 of *A. hyrcanus* and 3 of *A. barbirostris*, whereas in seven collections made from the same pond up to 22nd of the month, a wet period, there were only 72 larvae of *A. vagus* in a total of 1,697 other larvae. A further collection from the fishpond, on 26th August 1920, afforded no fewer than 628 larvae of *A. vagus*, 2 of *A. subpictus*, 5 of *A. fuliginosus*, 18 of *A. barbirostris* and 105 of *A. sinensis*.

It is evident, then, that no conclusions sufficiently valid to be of any practical value can be drawn as to the species of larvae to be found in a breeding-place from characteristics of its environment. Notwithstanding this, the object of the present paper is to advance the argument that Anophelines are not merely selective "to some extent," but are selective to a high degree, and that this selective tendency depends on other factors than the mere environment of a breeding-place. It will be shown in the case of *A. aconitus*, to which study was largely restricted, that choice has been constant over a very long period of time, there being other comparable situations available in which none of these larvae were found. An attempt will be made to consider some of the factors on which such choice may well depend.

*A. aconitus* is one of the dominant Anophelines of the Malay States. In Kuala Lampur it is certainly the most abundant of all, a total of no less than 5,753 adult specimens out of a grand total of 11,001 of these mosquitos having been obtained in about nine months by the writer in the course of some work having as its object the determination of the seasonal prevalence, if any, of mosquitos. It is an open-country breeder and, as has been pointed out by Dr. Hacker in the report referred to, has a preference for large reedy ponds and open deep swamps, being there associated with *A. barbirostris*, *A. hyrcanus*, *A. fuliginosus*, *A. subpictus* var. *malayensis* and some other species.

For the purpose of estimating the constancy of this Anopheline in her selection of a breeding-place it was arranged that collections, to include all Anopheline larvae, should be made at a particular place, a large open reedy swamp in low-lying ground on the outskirts of the town and subject to periodic inundation by the overflow from various streams. During a period of drought it became dry over a large area, but water was constantly found in the small open ponds which still remained. In this swamp preliminary examinations had shown the presence of a large number of these particular larvae. Collections were made here at irregular intervals during October up to the 20th. Thereafter they were made twice weekly by the same number of collectors, seven; working on each occasion for the same period of time, about three hours.

Until the absolute certainty of their determination by microscopic examination had been realised, the larvae in each collection were determined by breeding out. When, after an examination of hundreds, no single error had been found (for species difficult to determine by larval examination did not come into consideration) this

unnecessary labour was dispensed with and sole reliance was placed on the use of the microscope for identification purposes. The larvae in each collection were determined shortly after their arrival in the laboratory, and the results are given in full in the following Table I.

TABLE I.

| Date. | *A. aconitus.* | *A. barbirostris.* | *A. hyrcanus.* | *A. fuliginosus.* | *A. vagus.* | *A. kochi.* |
|---|---|---|---|---|---|---|
| 6.x.20 .. .. .. | 714 | 5 | 1 | 1 | — | 1 |
| 9.x.20 .. .. .. | 210 | 6 | — | — | — | 2 |
| 11.x.20 .. .. .. | 428 | — | — | — | — | — |
| 12.x.60 .. .. .. | 259 | — | 2 | — | — | — |
| 15.x.20 .. .. .. | 569 | — | — | — | — | — |
| 19.x.20 .. .. .. | 477 | — | — | — | — | — |
| 20.x.20 .. .. .. | 427 | — | 12 | — | — | — |
| 23.x.20* .. .. .. | 236 | — | — | — | — | — |
| 25.x.20 .. .. .. | 337 | — | 3 | — | — | — |
| 26.x.20 .. .. .. | 770 | 3 | 7 | — | — | — |
| 27.x.20 .. .. .. | 218 | — | — | — | — | 1 |
| 30.x.20 .. .. .. | 24 | — | — | — | — | 1 |
| 4.xi.20 .. .. .. | 128 | — | — | — | — | — |
| 12.xi.20 .. .. .. | 135 | — | — | — | — | — |
| 15.xi.20 .. .. .. | 408 | 45 | 21 | 6 | — | — |
| 18.xi.20 .. .. .. | 381 | 23 | 24 | 11 | — | 1 |
| 25.xi.20 .. .. .. | 84 | 8 | 15 | — | 1 | 8 |
| 29.xi.20 .. .. .. | 49 | 17 | 56 | 2 | 1 | 5 |
| 2.xii.20 .. .. .. | 14 | 25 | 137 | — | — | 11 |
| 6.xii.20 .. .. .. | 48 | 106 | 340 | 4 | — | 4 |
| 9.xii.20 .. .. .. | 198 | 61 | 109 | 2 | 1 | — |
| 13.xii.20 .. .. .. | 468 | 132 | 155 | 12 | — | — |
| 16.xii.20 .. .. .. | 181 | 91 | 114 | 4 | — | — |
| 20.xii.20 .. .. .. | 572 | 62 | 170 | 2 | — | — |
| 22.xii.20 .. .. .. | 355 | 105 | 90 | 9 | — | 1 |
| 28.xii.20 .. .. .. | 55 | 192 | 80 | 19 | — | — |
| 30.xii.20 .. .. .. | 61 | 204 | 136 | 29 | — | — |
| 3.i.21 .. .. .. | 405 | 256 | 137 | 21 | — | — |
| 7.i.21 .. .. .. | 262 | 137 | 62 | 23 | — | — |
| 10.i.21 .. .. .. | 392 | 167 | 152 | 25 | — | — |
| 13.i.21 .. .. .. | 286 | 91 | 69 | 14 | — | — |
| 17.i.21 .. .. .. | 150 | 160 | 30 | 5 | — | — |
| 21.i.21 .. .. .. | 134 | 169 | 29 | 3 | — | — |
| 24.i.21 .. .. .. | 215 | 75 | 131 | 9 | — | 2 |
| 27.i.21 .. .. .. | 268 | 123 | 72 | 7 | — | — |
| 31.i.21 .. .. .. | 200 | 236 | 51 | 11 | — | — |
| 3.ii.21 .. .. .. | 141 | 75 | 95 | 19 | — | — |
| 7.ii.21 .. .. .. | 78 | 44 | 23 | 5 | — | — |
| 14.ii.21 .. .. .. | 128 | 98 | 28 | 16 | — | — |
| 17.ii.21 .. .. .. | 101 | 194 | 60 | 15 | — | — |
| 21.ii.21 .. .. .. | 68 | 250 | 28 | 6 | — | — |
| 24.ii.21 .. .. .. | 74 | 29 | 10 | 13 | — | — |
| 28.ii.21 .. .. .. | 126 | 248 | 38 | 58 | — | — |
| 3.iii.21 .. .. .. | 72 | 135 | 46 | 46 | — | — |
| 7.iii.21 .. .. .. | 120 | 132 | 37 | 41 | — | — |
| 10.iii.21 .. .. .. | 200 | 160 | 37 | 4 | — | — |
| 14.iii.21 .. .. .. | 120 | 160 | 97 | 12 | — | — |
| 17.iii.21 .. .. .. | 72 | 72 | 29 | 7 | — | — |
| 21.iii.21 .. .. .. | 20 | 213 | 20 | 17 | — | — |
| 24.iii.21 .. .. .. | 10 | 8 | 3 | 11 | 1 | — |
| 29.iii.21 .. .. .. | 105 | 191 | 12 | 12 | — | — |
| 31.iii.21 .. .. .. | 80 | 150 | 70 | 3 | — | — |
| 4.iv.21 .. .. .. | 62 | 114 | 57 | 3 | — | — |
| 7.iv.21 .. .. .. | 200 | 110 | 100 | 25 | — | — |
| 11.iv.21 .. .. .. | 53 | 67 | 123 | 27 | — | — |
| Totals .. | 11,938 | 4,949 | 3,118 | 559 | 4 | 37 |

* *A. tessellatus*, 1.

During the period from October to April, then, the larvae of *A. aconitus* were found constantly and in such abundance that they almost outnumbered the larvae of the seven other species of Anophelines taken at the same time.

The overwhelming dominance of this species over all others up till the end of October, and thereafter the sudden relative increase in the others, is incidentally to be noticed.

For the purpose of comparison, larvae were collected under similar conditions regularly twice a week from 1st November from another breeding-place, distant about a mile in direct line from the former one, where preliminary investigations had shown the absence of the larvae of *A. aconitus*, though other members of Dr. Hacker's Group 2 were excessively abundant. This was a very large artificial pond about 50 yards square and kept free from reeds and coarse vegetation. It seemed to be of more or less uniform depth, which averaged four to five feet, and it was used by the Chinese owners for the cultivation of fish. The data obtained by these collections are given in the following table :—

TABLE II.

| Date. | *A. aconitus.* | *A. barbirostris.* | *A. hyrcanus.* | *A. fuliginosus.* | *A. subpictus.* | *A. vagus.* |
|---|---|---|---|---|---|---|
| 29.x.20 .. .. .. | — | 57 | 26 | 5 | — | 3 |
| 1.xi.20 .. .. .. | — | 36 | 17 | 7 | 1 | 23 |
| 19.xi.20 .. .. .. | — | 24 | 48 | 6 | — | 19 |
| 20.xi.20 .. .. .. | — | 36 | 132 | 6 | — | — |
| 25.xi.20 .. .. .. | — | 51 | 201 | 4 | 1 | 3 |
| 26.xi.20 .. .. .. | — | 82 | 97 | — | 1 | — |
| 30.xi.20 .. .. .. | — | 94 | 116 | 3 | — | — |
| 3.xii.20 .. .. .. | — | 62 | 133 | — | — | 5 |
| 7.xii.20 .. .. .. | — | 30 | 150 | 2 | — | 2 |
| 10.xii.20 .. .. .. | — | 42 | 157 | 3 | — | 18 |
| 14.xii.20 .. .. .. | — | 103 | 208 | 13 | — | 22 |
| 17.xii.20 .. .. .. | — | 98 | 108 | 4 | — | 10 |
| 21.xii.20 .. .. .. | — | 242 | 175 | 1 | 1 | 11 |
| 24.xii.20 .. .. .. | — | 52 | 92 | — | 9 | 4 |
| 28.xii.20 .. .. .. | — | 93 | 76 | 4 | 9 | 57 |
| 31.xii.20 .. .. .. | — | 155 | 170 | — | — | 16 |
| 4.i.21 .. .. .. | — | 97 | 51 | — | — | — |
| 7.i.21 .. .. .. | — | 70 | 87 | — | — | 5 |
| 11.i.21 .. .. .. | — | 114 | 47 | — | — | — |
| 14.i.21 .. .. .. | — | 100 | 73 | — | — | 2 |
| 20.i.21 .. .. .. | — | 44 | 39 | — | — | 36 |
| 21.i.21 .. .. .. | — | 76 | 40 | — | — | 4 |
| 25.i.21 .. .. .. | 2 | 25 | 167 | 2 | 4 | 110 |
| 28.i.21 .. .. .. | — | 110 | 80 | — | — | 7 |
| 1.ii.21 .. .. .. | — | 55 | 263 | 7 | — | 40 |
| 4.ii.21 .. .. .. | — | 74 | 230 | — | — | 22 |
| 7.ii.21 .. .. .. | — | 54 | 100 | — | — | 15 |
| 11.ii.21 .. .. .. | — | 11 | 88 | — | — | 2 |
| 15.ii.21 .. .. .. | — | 51 | 332 | 3 | — | 11 |
| 18.ii.21 .. .. .. | — | 48 | 240 | 1 | — | 13 |
| 22.ii.21 .. .. .. | — | 60 | 371 | — | — | 13 |
| 25.ii.21 .. .. .. | — | 15 | 289 | 1 | — | 36 |
| 1.iii.21 .. .. .. | — | 34 | 259 | — | 1 | 36 |
| 4.iii.21 .. .. .. | — | 16 | 152 | — | — | 2 |
| 8.iii.21 .. .. .. | — | 13 | 401 | 2 | — | 26 |
| 11.iii.21 .. .. .. | — | 17 | 229 | — | — | 4 |
| 15.iii.21 .. .. .. | — | 11 | 304 | 1 | — | 1 |
| 18.iii.21 .. .. .. | — | 4 | 113 | 3 | — | — |
| 22.iii.21 .. .. .. | — | 13 | 115 | 9 | — | 3 |
| 29.iii.21 .. .. .. | — | 3 | 53 | — | — | 244 |
| 1.iv.21 .. .. .. | — | 80 | 200 | — | — | 9 |
| 5.iv.21 .. .. .. | — | 18 | 177 | 1 | 4 | 130 |
| 8.iv.21 .. .. .. | — | 20 | 247 | 3 | — | 120 |
| Totals .. | 2 | 2,589 | 6,743 | 91 | 31 | 1,093 |

The entire absence of *A. aconitus*, except for two individuals, in a collection numbering 10,549 and comprising five other species, as shown in Table II, offers a most striking contrast to its relative proportions in the parallel collections, as shown in Table I, in which out of a total of 20,605 larvae, including six other species, no fewer than 11,938 were those of this Anopheline. To what causes can its absence be due? To what is due the overwhelming abundance of this species elsewhere? If due to differences in the nature of the breeding-places, in what do these consist?

The mere presence of reeds, affording a measure of shade, would hardly seem to account for it, as the larvae were obtainable elsewhere in situations entirely free from such growth and exposed to the overhead sun. The difference in size of the ponds and the depth of the water has also no bearing on the matter: one knows of other breeding-places equal in point of size and depth of water, in some of which the larvae of *A. aconitus* are found though absent in others.

For further study of the question of selection of breeding-place, a little group of four other small ponds and one little reedy swamp on the outskirts of another quarter of the town were selected in March 1921. The relative position of these is shown on the accompanying map (fig. 1).


Fig. 1. Sketch-map to show the relative positions of the ponds examined for *Anopheles* larvae.

The swamp (L) is a natural feature : the ponds (K, N, O, P) were probably old mining holes, and were approximately of the same size and depth.

The swamp is a shallow one, overgrown with reeds and coarse grass, but open here and there with large stretches probably of deep water. At the time collections were made a slow current of water was moving. The larvae here obtained by two collections are shown in the following table :—

| Date. | *A. aconitus.* | *A. barbirostris.* | *A. hyrcanus.* |
|---|---|---|---|
| 23.iii.21 .. .. .. | 98 .. | 47 .. | 18 |
| 31.iii.21 .. .. .. | 65 .. | 8 .. | 17 |

The pond (K) was a collection of stagnant water situated among young Hevea trees, but unshaded from the overhead sun. A few tufts of coarse vegetation grew in one corner but, apart from that, it was almost free from floating aquatic plants.

The larvae obtained by two collections are shown in the following tables :—

| Date. | *A. aconitus.* | *A. barbirostris.* | *A. hyrcanus.* |
|---|---|---|---|
| 22.iii.21 .. .. .. | 52 .. | 9 .. | 9 |
| 31.iii.21 .. .. .. | 8. .. | 37 .. | — |

Thus in breeding-places (K) and (L), close together, but showing very different characteristics, *A. aconitus* was by far the most dominant species in three collections, though in the fourth, that obtained on 31st March, there was a marked diminution in the numbers obtained.

Ponds (N) and (O), situated about 100 yards away from pond (K) and swamp (L), were characterised by a dense growth of large surface aquatic plants, with rushes and some reeds here and there at the margins. On pond (N) the surface plants were chiefly the " Japanese Hyacinth " and " Cabbage weed " and on pond (O) the latter only. These plants were probably more or less cultivated by a Chinese farmer, for they are used for the purpose of feeding pigs.

The following larva collection was obtained from pond (N) :—

| Date. | *A. aconitus.* | *A. barbirostris.* | *A. hyrcanus.* |
|---|---|---|---|
| 5.iv.21 .. .. .. .. | — .. | 197 .. | 42 |

In pond (O) the following larvae were obtained :—

| Date. | *A. aconitus.* | *A. barbirostris.* | *A. hyrcanus.* | *A. fuliginosus.* |
|---|---|---|---|---|
| 5.iv.21 .. .. .. | — .. | — .. | 90 .. | 40 |

The remaining breeding-place examined was a pond of stagnant water (P) more shaded by trees than the four other places and situated within 50 yards of a Chinese house and about 250 yards from the other breeding-places. Tufts of grass dotted the surface thinly, and there was no surface vegetation. Neither was there any vegetation on the banks. A collection made here afforded the following larvae :—

| Date. | *A. aconitus.* | *A. barbirostris.* | *A. sinensis.* | *A. fuliginosus.* |
|---|---|---|---|---|
| 5.iv.21 .. .. .. | — | 6 | 8 | 76 |

There is difficulty, therefore, in believing that any outward characteristics of a breeding-place influence the preference of *A. aconitus*. To what causes, apart from these, can the differences in distribution be due ? In view of the abundance of Anophelines, their fertility and, so far as is known, the comparative freedom of their larvae from attack by natural enemies, it might be thought that oviposition is entirely haphazard, the female trusting to lucky chance, like some of the Bombyliid flies for

instance, that a few of her ova, more fortunately placed than the majority, will ultimately afford imagos to carry on her race, the larvae which develop from ova less fortunately dropped dying out. For example, an *A. maculatus* may be presumed to have oviposited without having exercised any great selection in a fish-pond, a small shallow muddy pool, and a deep sheltered grassy drain. The latter situation is one in which the larvae are commonly found, and their occurrence may be a measure of the suitability of the place, the larvae developing from ova deposited on the other waters perishing at an early stage. But judging by what one sees in the case of other insects, the presence of *A. aconitus* in the situations referred to is more likely to be due to a very judicious selection by the female parents in the best interests of their offspring.

It is a far more general rule in the insect world that the female parent deposits her ova with almost unfailing precision in the situations best suited for the welfare of the larvae. For instance, the female butterfly, of species having leaf-eating larvae, lays her eggs almost invariably on the softest and most succulent part of the food-plant, often selected after a search lasting hours, and probably days, so giving her offspring the best possible start in life ; she will often die in captivity rather than oviposit on an unsuitable plant. Some of the myrmecophilous LYCAENIDAE oviposit in the very track of ants, so ensuring the due carriage of the egg to the ants' nest ; and, as the writer showed in the case of a species having larvae with predacious habits, the butterfly is at pains to oviposit actually on the particular little " bug " on which its larva feeds. The female tsetse-fly exercises such meticulous discrimination in regard to the choice of a spot in the earth in which to deposit her maggot that, though the fly swarms in certain districts of Africa, its breeding-places were discovered only after long and patient search by skilled observers. The bot-fly deposits its ovum more often than not on a part of the coat where it can most readily be reached by the tongue of its equine host.

Some definite evidence of selection by *Culex fatigans* as to its breeding-places was obtained by examination at Kuala Lampur of a number of pools—about fifteen—made by the passage of carts and transport animals through soft clayey soil at the side of the road. On only three were the egg rafts of the *Culex* found, and then in numbers on each—four on one pool, three on a second and seven on a third. All the pools were under the same conditions in regard to exposure ; all were absolutely unshaded ; there was no grass round any ; there appeared to be an equal absence in all of small vegetation, and there was no great variation as regards depth.

Some experimental evidence bearing on the question was obtained in the laboratory in the case of this *Culex*. In three large vessels water, in which on 13th August rice had been boiled, was left standing. The water soon became fetid and a white downy fungus growth developed. On the surface of the water in one of the jars a *Culex* raft was discovered on 20th August : a second was found on 22nd and a third on 26th, none at all being deposited on the control vessels, side by side with the first. The dissociation of the eggshells comprising a raft may take a considerable time after the hatching of the larvae, so that a raft may long serve to attract an ovipositing female.

Laboratory experience with *Stegomyia albopicta* was precisely the same. This mosquito was an absolute nuisance by reason of its ovipositing in vessels containing the larvae of various Anophelines, so necessitating the constant removal, for the sake of the Anophelines, of their stronger and more active competitors. The ova were found day by day in the same particular bowls, though others containing similar Anopheline larvae in water from the same place were available. The careful selection made even by this mosquito was further exemplified by the discovery in the laboratory, on 17th August, of 46, and on 30th August, of 72 ova, on the water of the same bowl, the only one in which *Stegomyia* was being reared out of twenty-five all full of water, and kept under the same conditions as regards temperature and light.

It is therefore only in accordance with expectation that the female Anopheline, also, should exercise very careful selection of a breeding-place. Were there not masses

of data available, such as have been quoted as to *A. aconitus*, there is strong presumptive evidence for careful selection on the part of *A. maculatus* that, when hard pushed for favoured breeding-places, it does not seem to avail itself of other collections of water. The water which formerly stagnated in the open ravines round Federal Hill and Carcosa in Kuala Lampur at one time swarmed with larvae of *A. maculatus*, which have now almost been eradicated through the application of engineering science (subsoil pipes, open concrete drains, etc., most judiciously laid) to entomological observation. But though the species must here be very hard pushed for breeding-places, it would seem still to show its marked preference for such a type of breeding-place by depositing its ova at any point in the drains where any little temporary deficiency of the work, even a mere fissure in the cement, affords water sufficiently still. The Anopheline does not seem to select other possible breeding-places. Though a large sheet of open water is available, the writer found on one occasion only two or three of these larvae in it and, though under his direction an examination was made of numerous possible breeding-places in the neighbourhood, which afforded a vast number of *Stegomyia*, in no single instance was *maculatus* obtained.

It is, therefore, at least probable that the presence of larvae of *A. fuliginosus*, found in large numbers in almost pure culture in a pond near Kuala Lampur, was due to careful parental selection, 149 being obtained on one occasion with one of *A. hyrcanus*; and 100 more, six days later, at the same place.

Dr. Malcolm Watson related to the writer how, many years ago, when a road was cut through a hill at Klang, he made search for Anopheline larvae in the springs exposed. In one only did he find them, and in this a cow had deposited manure. The larvae were those of *A. vagus* and they were of all sizes. This experience was parallelled by one of the writer's, for in the course of a search for larvae of this species, in a number of cart ruts and hoof prints, in only three out of about a dozen were they found. The larvae were those of *A. vagus* in considerable numbers and of various sizes, so, most probably (though not necessarily, since the size of a larva is not always a guide to its age) the progeny of several females.

Assuming that there is refined selection by the ovipositing Anopheline, what are the influences likely to guide her in her choice? One supposition was that the presence of already existing larvae might attract the female.

To the naturalist, acquainted with instances of far more delicate perceptions on the part of insects than would be called for in the detection by an Anopheline of the larvae of its own species, there is no difficulty at all in supposing that a female *A. vagus*, for instance, having discovered the few small pools from which were taken on 18th August no less than 250 larvae of her own species, 95 others too small to be classified with certainty and 49 pupae probably of this species, might well be influenced in her decision to oviposit by the evidence of conditions so auspicious to the offspring of others; and that a pregnant *A. maculatus* might be similarly influenced on arriving at a grassy drain from the water of which were readily collected, on 21st July, 283 of these larvae, on 30th July 222, on 28th July 183, and on 4th August 126, with a considerable number of pupae on each occasion.

It seemed as if the point might readily be settled by affording captive mosquitos the alternative opportunity of ovipositing on plain tap water, and tap water containing larvae corresponding to the species experimented with. This was attempted, two bowls of plain water and one containing the larvae being supplied, in a long series of experiments, to ovipositing females of various species. No predilections by the female parents were discovered for the bowls containing the larvae, the greater number of the batches of ova being deposited on the plain water.

Had positive results been obtained, they would have afforded useful data, but it was impossible to make such an experiment under perfectly natural conditions. The mosquitos, though carefully fed and screened from an undue amount of light during the day, bore captivity hardly, injuring themselves in their almost constant endeavour

to escape. It is therefore probable that all other instincts were subordinated to those of self-preservation, and that oviposition was effected only when it could be no longer deferred, and then in the first bowl on which the insect happened to chance.

However, the female mosquito, like other insects, is probably influenced in her choice primarily by the odours characteristic of particular spots, which connote the general suitability of the situation as to temperature, composition of water, presence of particular foods. The guiding odours may or may not be such as are perceptible to the imperfect sense of smell possessed by the ordinary human being. For instance, *A. umbrosus*, breeding largely in jungle pools (when away from the coast), may conceivably be attracted thereto by the moist rich smell of the rotting leaves necessarily associated with the presence of shade and of water, conditions which may afford these larvae suitability of temperature and may favour the growth of the foods on which they depend. The odour of many breeding-places which harbour the larvae of *A. vagus* in the neighbourhood of native habitations is often such as grievously offends the nostrils and may well serve to attract the mosquitos from afar to oviposit. The water in which large collection of *A. aconitus* was obtained seemed to be almost odourless to human nostrils.

If odour influences the female it should be possible to mask it experimentally by adding to the water of a breeding-place a strongly odorous substance, the expectation then being that the female, repelled by it, or unable to detect the guiding odour, would no longer oviposit. The two bodies with pungent odours which first came to mind were chlorine and formalin ; and a test was made with the latter. The breeding-place selected was a pool in secondary jungle of considerable size, long known to be favoured as a breeding-place by *A. umbrosus*. This had the advantage that it was of the size suitable for such an experiment ; it was in a shaded situation, in which, owing to the improbability of rapid evaporation, the formalin was likely to be effective over a longer period than in a pool out in the open ; and the data in reference to the collection of larvae from it extended over a considerable period of time, showing that it was an old-established breeding-place. Formalin was added, until a very faint odour was perceptible and this was detected again a few hours later. Thereafter collections of larvae of *A. umbrosus* were made after four or five days. The addition of so small an amount of formalin would probably have little effect on larvae already approximating maturity but, besides preventing oviposition, might well also prevent hatching, or might have a prejudicial effect on young and delicate larvae. But no results at all were obtained, for the larvae were as numerous after the experiment as before it.

No ova of *A. umbrosus* were available for experimental purposes, but about half of a batch of 166 freshly laid ova of *A. vagus*, placed on a solution of formalin just strong enough to afford a perceptible odour, duly hatched out equally well as the control half, and the young larvae seemed unaffected for three days, moving their mouth brushes as if hoping to obtain food. They then gradually died off. An attempt to obtain positive evidence of the predilections of the female Anopheline as to waters was made by supplying the captive insects with two alternative waters in addition to some from the breeding-place in which the larvae were readily obtainable in the expectation that they would select the latter. The water samples were placed in small bowls side by side in lamp glasses containing the insects. The results, again, were entirely negative ; no preferences were shown. But here again the experiments are open to the objection that the insects were bent mainly on self-preservation. Furthermore the odours from the different waters may well have blended, so misleading the insects, or may have been lost, the gases in solution coming off rapidly in the tropics.

The question as to how far the larvae of different species can thrive in waters other than those in which they are usually found seemed a more promising line of investigation and was initiated by a series of experiments made with a view to determining if the hatching of the ova of the various species is, to any degree, prejudiced by their transfer to water in which they are not usually found. The results of the experiments were again negative where natural waters were concerned.

The newly laid ova of *A. aconitus*, for instance, which were tested on tap water and on the water from small muddy pools on unfrequented roads, from the fishpond referred to, from the cesspit of a Chinese house, and from a jungle pool, all hatched. The ova of *A. aconitus* and of *A. vagus* duly hatched when transferred within a few hours of oviposition to water which had been thoroughly boiled a few hours previously.

An experiment of some interest consisted in the transfer of 67 newly laid ova of *A. vagus* to water in which rice had been boiled a few days previously and which was therefore acid and malodorous, the rice fragments forming a culture medium for a species of mould. No hatching at all took place, though of 25 ova of the same batch tested as a control on fresh water every single one hatched. Though this medium was so unpropitious to this species of Anopheline it turned out to be singularly favourable to a species of *Culex*, three rafts of ova deposited thereon affording hundreds of larvae which fed up first on the moulds and then on the rice fragments, so that the water became clear, and being placed in a light situation developed, at the end of about a month, a strong growth of green algae. These were allowed to thrive undisturbed for another month, when more ova of *A. vagus* were transferred to it. These now hatched and the larvae attained about half size, then succumbing. A sufficiency of nutritive matter for the development of algae may perhaps explain the very occasional presence of Anopheline larvae in artificial breeding-places. In another similar experiment about 80 ova of *A. vagus* were placed on the medium. All failed to hatch, though 10 ova, as a control on tap water, duly afforded larvae. A succession of larvae of *Stegomyia albopicta*, hatching from eggs deposited by stray females on the material, which was in an open glass jar exposed in a well-lighted situation, bred up, though during such time as the medium remained acid and foul, newly hatched larvae of *A. vagus* transferred to it soon perished.

By way of further experiment 20 ova of *A. vagus* and an equal number of those of *S. albopicta*, all newly laid, were placed on the surface of a thin mucilage of rice boiled up two days previously. Most of the eggs of the *Stegomyia* hatched, but the majority of the larvae died, though one managed to survive until the tenth day. Not a single larva of *A. vagus* hatched, although control ova duly afforded larvae.

The ova, then, would hatch on all normal media. The growth and development of larvae in water from breeding-places other than those in which the species experimented with is usually found was also made the subject of enquiry. The results again were not in accordance with expectation: the larvae of the various open-country species could be bred in the laboratory to maturity in natural media in which numerous examinations had shown constantly the entire absence of the larvae of the species under experiment. For instance, almost within a stone's throw of the swamp referred to (Table I) in which the larvae of *A. aconitus*, *A. hyrcanus*, *A. fuliginosus* and *A. barbirostris* were found in such great abundance, there was a large pond of stagnant water, well shaded by rubber trees, varying in size according to season, but during most of the year, about ten yards wide and twenty long, with a depth of one to three feet. The water, surface drainage, partly from a road and partly from a plantation in which there was a small Chinese and Malay settlement, was always turbid and sometimes malodorous both from vegetable and animal pollution, and a green scum, due to the presence in almost pure culture of Protozoa (determined by Dr. Stanton as a species of *Euglena*, probably *viridis*) was present on the surface during the period the investigation was carried out. The only Anopheline larvae ever found in this water, in spite of their proximity in such great abundance in the water of swamp (A) near by, were those of *A. vagus*, and these but sparingly. In view of the scantiness of these particular larvae, suggesting rather unfavourable environment (since they abounded in road pools near by) and of the entire absence of other species, suggesting complete unsuitability of conditions for them, any success in breeding the open-country Anophelines in this water was hardly to be anticipated. But expectations were falsified; the water proved to be the best medium of many tried by the writer

for the purpose, and it was used for rearing for the study of variation and other purposes large families of these mosquitos from known female parents. The results will be presented in another paper; for the purpose of the present one it will suffice to give a few of the data obtained. These are given in the following Table III.

TABLE III.

| Species. | Number of ova. | Number of adults obtained. | | |
|---|---|---|---|---|
| | | Males. | Females. | Totals. |
| *A. aconitus* .. .. .. .. | 176 | 47 | 35 | 82 |
| | 91 | 30 | 31 | 61 |
| *A. barbirostris* .. .. .. .. | 98 | 30 | 14 | 44 |
| | 115 | 39 | 30 | 69 |
| *A. hyrcanus* .. .. .. .. | 75 | 42 | 31 | 73 |
| | 117 | 41 | 40 | 81 |
| *A. maculatus* .. .. .. .. | 30 | 9 | 17 | 26 |
| | 68 | 17 | 15 | 32 |
| *A. karwari* .. .. .. .. | 97 | 20 | 27 | 47 |
| *A. subpictus* var. *malayensis* .. .. | 88 | 37 | 20 | 57 |
| | 97 | 32 | 29 | 61 |
| *A. vagus* .. .. .. .. .. | 146 | 42 | 33 | 75 |
| | 72 | 23 | 23 | 46 |
| *A. ludlowi* .. .. .. .. | 120 | 14 | 22 | 36 |
| | 50 | 14 | 6 | 20 |
| *A. fuliginosus* .. .. .. .. | 46 | 22 | 18 | 40 |
| | 75 | 16 | 18 | 24 |
| *A. kochi* .. .. .. .. .. | 110 | 31 | 53 | 84 |
| | 82 | 20 | 18 | 38 |
| *A. tessellatus* .. .. .. .. | 38 | 10 | 3 | 13 |

The surprising fact arises, then, that all the common Anophelines could be bred from the egg in a medium in which none except *A. vagus* existed in nature. A still more surprising result was that any success at all was met with in the case of *A. ludlowi*, a species limited in the Federated Malay States (though not in Java) to the coastal area, by reason of its preference for brackish pools as breeding-places. The case is the more interesting by reason of the observation made by Dr. Hacker, that when the salinity of breeding-places favoured by this species becomes diminished owing to rainfall the larvae are no longer found, but may be replaced by those of *A. vagus*.* All the results were not uniform, however. It was found, especially with *A. aconitus*, that unless the water was changed daily, the larvae soon died out (neglect to change it on a Sunday caused the death of several broods), and that other larvae, especially *A. maculatus* and *A. vagus*, though less prejudicially affected, often maintained themselves in such water unchanged for several days. On one occasion a number of larvae of *A. aconitus*, comprising two families and numbering 108, had thrived to such a degree in this *Euglena*-containing water that their pupation was expected within a day or two. On transfer of the larvae one morning to fresh bowls of water it was noticed that fetor was arising from it and, as it had already been appreciated that these larvae are more delicate than others, some misgiving was felt as to them. These fears were soon realised; the larvae ceased to feed continuously, the mouth-brushes working intermittently only, and within 36 hours the whole of both families had perished, the larvae of the other species changed into similar water being apparently uninfluenced. It was to be expected that the larvae of this species would succumb in any foul water. To test this, about half of a batch of 59 ova were placed on 9th

* F.M.S. Malaria Bureau Reports, ii. p. 38.

March on malodorous sewage water obtained from the drain of a Chinese house in which the larvae of *A. vagus* had been sparingly obtained ; the other half were placed, as a control, on tap water. The eggs hatched on both media, and, entirely contrary to expectation, the young larvae on the foul medium did not succumb forthwith, for on 19th March, eight days after hatching, there were as many as 15. Two only eventually pupated and emerged. In two similar experiments three larvae out of 76 ova were bred almost to maturity, then dying. But attempts to rear the larvae of *A. aconitus* in water from the fishpond A, in which they were so consistently absent, were entirely unsuccessful even when the water was changed daily. The larvae hatched, but their numbers gradually dwindled so that usually within a week all had perished. For example, on 31st December 50 ova of the Anopheline were transferred to this water. By 6th January most had hatched, but by 8th January all were dead in spite of their being transferred daily to a fresh supply of the water. A modification of this experiment consisted in the transfer on 6th January of 101 of these larvae which hatched on 2nd January and were thriving on *Euglena*-containing water, to the fishpond water. Within two days all were dead. A further modification of the experiment was the following :—An *A. aconitus* laid on 30th April 70 ova on water from a small muddy pool. The ova were transferred to fishpond water, and the larvae hatching on 3rd May were then transferred to similar water half-diluted with water from a breeding-place natural to the species, and changed daily. By the time they were three days old it was found that fully half were dead, and a note was made that the other half were combing their tails with their mouth-brushes (usually a sign of ill-health with Anopheline larvae), and that they showed a sluggish response to stimuli, though the reaction was quickened on the addition of tap water. By 8th May all were dead.

Such was the outcome of many experiments on these lines with *A. aconitus*. But unfortunately for the interpretation to be put on them, there was some difficulty also in breeding in the fishpond water the larvae natural to it, *A. barbirostris* in particular, and *A. hyrcanus*; but the failure was rarely so complete as with *A. aconitus*, a few larvae, out of large numbers, being invariably reared. But though the collection data and the experimental facts are largely in direct conflict, the outstanding facts are the eclecticism of *A. aconitus* as to breeding-places and the inability of its larvae to maintain themselves in the fishpond water. To account for this, one must suppose that the food supply is unsuitable, for the algal flora was markedly different from that in the swamp, or that some quality of the water is prejudicial to the larvae.

It was anticipated that by systematic dissections of larvae freshly taken from various breeding-places it might be possible to ascertain precisely the various algal forms favoured as food material, and so define one of the main factors determining oviposition and larval prevalence. Large numbers of larvae, killed instantly on capture by immersion in 20 per cent. formalin solution, were dissected, and the contents of the alimentary canal were examined microscopically ; but without the very special knowledge of aquatic plants required it was impossible to arrive at any definite determination of the organisms, which were largely in a fragmentary state.

An examination of the excreta of various species of larvae fed in the laboratory on *Euglena* afforded an interesting comparison. So abundant was the organism, and so active, that there was no need for the larvae to swim about in search of food, and it was usual for the larvae, even of species favouring moving water, *A. maculatus* and *A. karwari* for instance, to remain anchored hour after hour at a particular spot, if undisturbed, feeding constantly with a steadily accumulating pile of excreta below them, often equalling them in bulk. The pellets were readily removed and examined microscopically. With most of the Anophelines it was possible to identify with certainty the *Euglena* fragments. But though some success was met with in rearing to maturity on the medium a number of small larvae of *A. leucosphyrus*, a bush breeder, 31 out of 51 affording imagos, total failure was experienced with the larvae

of *A. albotaeniatus* var. *montanus*, another but rarer bush-breeding species, nine larvae of which were brought in at the same time. An examination of the excreta of the former showed that digestion must have been largely complete whereas the excreta of the latter, though very bulky, consisted almost entirely of the organism not broken up at all. In the laboratory the larvae of *A. maculatus* and *A. karwari* showed an appreciation as a food of a species of *Spirogyra*, found usually in the breeding-places of the former, and when the filaments were broken up, they could be seen nibbling constantly at the broken ends where they reached to the surface. On this plant in tap water a small family of *A. maculatus* was bred to maturity, but examination of the excreta failed to reveal any particles whereby the nature of the food could have been determined with certainty.

Without very special knowledge of aquatic micro-organisms it was found impossible to arrive at any determination of their character and to decide the question of the food preferences, if any, exhibited by larvae. It is, however, well recognised that the nature of the algal flora depends very largely on what might be considered very small differences in the composition of the water ; differences in the nature and amount of salts, and even of the gases present. One finds in various works on algae numerous paragraphs emphasising the bearing of such differences on the character of algal growths. Since such factors may well account also for the features of larval distribution, it is of value to quote some of the more striking observations :—

In the well-known text-book by G. S. West on Algae the following passages occur :—

" A careful study of the constituents of the phyto-plankton in relation to the lake basins brings with it the conviction that the factor of greatest importance in both the qualitative and quantitative distribution of plankton is the amount and nature of the dissolved salts present in the water. The highest percentage of dissolved salts is found in those lakes which are contaminated from adjacent farms, villages and towns, and such lakes contain a greater bulk of plankton " (p. 443).

" Fresh-water algae occupy very varied habitats, and it is because habitat plays such an important part in both the occurrence and distribution of fresh-water algae that it is here made the basis of the treatment of the subject " (p. 418).

" Most of the algal vegetation of fresh waters can be regarded as forming associations of a more or less definite character, the peculiarities of which are the direct result of habitat, and the nature and amount of the dissolved salts in the water."

In a paper by Dr. F. E. Fritsch on the algal flora of Ceylon* one finds the following :—

" The character and distribution [of algal vegetation of inland fresh-waters] is dependent mainly on temperature, aeration and composition of water " (p. 201).

" There are amongst the Algae certain forms which are much more susceptible to such variations in environment and which are therefore of more limited distribution, and these are the forms which will characterise certain prevailing conditions in the surrounding medium. They are character-plants, which will help us to determine our aquatic formations, and it is requisite to study them primarily, and to determine the exact conditions which influence their presence and absence. Other species will then be found to be almost constantly associated with these character-plants and will make up the subordinate members of the association " (p. 202).

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* " A General Consideration of the Sub-aerial and Fresh Water Algal Flora of Ceylon." *Proc. Royal Soc.*, lxxix, 1907.

" Some of the tanks must certainly be rich in dissolved organic substances owing to the large amount of water-weeds they contain " (p. 223).

" The frequent presence of Characeae probably means dissolved carbonate of lime " (p. 223).

" The conditions of life of the macro-phytic algae are as follows : strong illumination ; high temperature of considerable range (varying from 6° to 10° C.) ; small amount of dissolved oxygen in the water " (p. 223).

" I think it probable that certain species are able to flourish better in small isolated pieces of water than in the large expanse of the waters of the tanks, and consequently attain to a degree of development in these pools during the dry season which is impossible except in such small collections of water " (p. 234).

" It is not easy to understand why the Conjugates play so important a part in the pools and ditches, while the Cyanophyceae are subsidiary to them " (p. 234).

Elsewhere (p. 36) are considered various algae which characterise the " Ferruginous pools," those which exhibit at the bottom a dense brownish-red deposit of ferric hydroxide, which also often constitutes a filmy investment to all the water-plants.

In connection with a further paragraph in the same publication discussing the periodicity of the algal growths in rice fields (p. 242) one may recall the results in Java of the Dutch workers, who showed that there is a gradual change in the character of the Anopheline fauna as the cultivation of the rice proceeds. The paragraph, which may well be pregnant with facts of significance as to the distribution of Anopheline larvae, runs as follows :—

" The periodicity of the algal growths in the rice fields would be an interesting study and would probably disclose interesting adaptations. It seems that the first growth is almost always blue-green and that the green element only appears subsequently when the rice and occasional water weeds (especially Characeae) afford a certain amount of protection against the strong light. Two fresh rice fields at Matale showed practically nothing but blue-green forms, whilst a slightly more advanced field at Matara contained abundant Oscillaria intermingled with occasional filaments of Spirogyra and Diatoms and Desmids in some numbers. Old rice fields often contained only very scanty Cyanophyceae, but in their place quite a rich Conjugate and Diatom flora."

No conclusions as to the food preferences of the various Anopheline larvae having been satisfactorily determined, some consideration of the question as to the constitution of waters affecting larval distribution seemed to be called for. Though such experimental evidence as has been adduced would seem to show that this has little bearing on the matter, the natural evidence would seem strongly to support the theory that the absence of *A. aconitus* is due to pollution, largely of vegetable origin.

The swamp water in which *A. aconitus* was dominant was, relatively to other waters in the neighbourhood of Kuala Lampur, less subject to pollution. Only on one side were there houses ; on another was a stream, the periodic rising of which ensured at fairly frequent intervals a flooding and wash-out of the whole swamp area. The water was never found to emit any odour, and it was fairly clear except at flood time. So far as memory serves, there were few, if any, of the large aquatic floating plants, which would have been preserved from being washed away by the floodings by the coarse grass and reeds abundant in the situation.

The fishpond, on the other hand, was subject to very considerable pollution. Some water drained into it after rain from the neighbourhood of Chinese dwellings and vegetable plots, which were manured, in accordance with the time-honoured

custom of that people, with decomposed human excreta. A hut with a plank flooring, built over the water on piles, accommodated a herd of goats, about 40, at night and during a part of the day, their dejecta dropping into the water; and three little shacks, also overhanging the water, provided cover for inhabitants proposing to indulge in the luxury of a bath. The vegetable pollution of this water must necessarily have been considerable owing to the method of fish cultivation adopted by the Chinese. A large amount of freshly chopped succulent grass is from time to time put into the water for the purpose of "fattening the fish," according to one of that people. The excreta of goats were said to serve the same purpose, for which in China, but not in the Malay States, bones also are put into the water. When there is thunder in the air it is the further practice to put in also chopped banana leaves by way of "medicine" for the fish, which are said to be then liable to sickness.

The fish may perhaps feed up on these vegetable matters—one is hardly in a position to express an opinion; but it would seem more than probable that they feed on the organisms, among which a species of *Euglena* was dominant, that on this and similar ponds formed an extremely dense semi-solid scum on the surface. The water, even when taken from below the surface, was green by reason of its high algal content and was often malodorous.

The additional use of these ponds for the cultivation of "cabbage weed" and other floating plants, which must depend on a large organic content in the water, has already been noted.

With regard to the other group of breeding-places, it would seem significant that those providing the larvae of *A. aconitus* were entirely remote from houses and were free from large aquatic plants, and that two of those in which these larvae were absent were in the neighbourhood of a Chinese farm. They were largely covered with floating weed, the growth of which may or may not have been encouraged in the usual way by the farmer, who kept pigs. These two ponds were from time to time used as wallows by buffalos, which, as is usual with Herbivora, would foul them on leaving.

The supposition is, therefore, that some quality of the water strongly affects the distribution of *A. aconitus*, either directly or indirectly, by influencing the character of the food, and it was hoped to determine the nature of this quality by water analysis. Various samples of water from these breeding-places were submitted to Mr. R. W. Blair, the Government chemist, who, though over-pressed with routine and other laboratory work, was so kind as to make time to carry out some preliminary analyses (see Table IV., p. 17). But at this important stage of the investigation the writer was obliged to go on leave and so no final conclusions were arrived at.

The results of the following technique as to *A. umbrosus* serve to show how larval distribution may be influenced by making an alteration in environment. A large pool, about 6 feet broad, 15 feet long and 1 to 1½ feet in depth, situated near Kuala Lampur in secondary bush, by which it was largely, though not entirely shaded from the overhead sun, had consistently afforded in fairly large numbers and in pure culture the larvae of *A. umbrosus*, a jungle breeder, at all events when away from the coast. The disappearance of the bush species, *A. aitkeni* and *A. leucosphyrus*, and their replacement by open country species on clearing, was recognised years ago by Dr. Fletcher and Mr. Pratt. The success which has attended Dr. Watson's attempt at Port Swettenham and Klang to eradicate *A. umbrosus* by clearing the bush and by draining has, of course, long since been appreciated; and Dr. Hacker has recorded an instance of the replacement of this species by *A. barbirostris* after clearing was effected.* For the sake of obtaining concrete data as to the effect of

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* F.M.S. Malaria Bureau Reports, i, p. 53.

TABLE IV.—RESULTS OF ANALYSES SUPPLIED BY MR. BLAIR.

*Analyses of Samples of Water.*

| | Date. | Source. | Colour. | Turbidity. | Suspended Matter. | Reaction | Parts per 100,000. Ammoniacal Nitrogen. | Albuminoid Nitrogen. | Oxygen absorbed 3 hours. | Chlorine. | Nitrites. | Oxidised Nitrogen. | Total Solids. | Iron | Sulphuretted Hydrogen. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Larvae of *A. aconitus* dominant. | 8.iii.21 .. | Swamp B | Greyish | Slightly Turbid | Some | Slightly Alkaline | ·0140 | ·0320 | ·4526 | 0·20 | .. | ·04 | 24·0 | — | — |
| | 31.iii.21 .. | Pond K | Very Brownish | Turbid | Some | Slightly Acid | ·0039 | ·0300 | ·2704 | ·65 | Nil | ·01 | 7·5 | + | — |
| | 9.iv.21* .. | Pond K | Slightly Brownish | Slightly Turbid | Nil | Neutral | ·0072 | ·0240 | ·2495 | ·70 | Nil | ·02 | 6·5 | + | — |
| | 31.iii.21 .. | Swamp L | Very Brownish | Turbid | Some | Slightly Acid | ·0014 | ·0240 | ·2580 | ·85 | Nil | ·01 | 8·5 | + | — |
| Larvae of *A. aconitus* absent. | 7.iii.21 .. | Pond C | Greenish | Slightly Turbid | Some | Neutral | ·0168 | ·4000 | 2·4770 | 1·10 | Nil | ·01 | 44·0 | — | — |
| | 11.iv.21* .. | Pond C | Brownish | Turbid | Nil | Neutral | ·0018 | ·0720 | ·7970 | 1·82 | Nil | ·002 | 16·50 | — | — |
| | 5.iv.21 .. | Pond N | Greyish | Turbid | Some | Neutral | ·0064 | ·1200 | 1·2639 | ·58 | Nil | ·01 | 47·0 | + | negative |
| | 9.iv.21* .. | Pond N | Brownish | Slightly Turbid | Nil | Neutral | ·0055 | ·0260 | ·4229 | ·72 | Present | ·00 | 7·5 | + | — |
| | 5.iv.21 .. | Pond C | Greyish | Turbid | Some | Neutral | ·0164 | ·1600 | 1·8354 | 1·45 | Nil | ·02 | 131·0 | + | negative |
| | 5.iv.21 .. | Pond P | Brown-grey | Turbid | Some | Neutral | ·0192 | ·1600 | 1·8644 | ·27 | Nil | ·02 | 301·0 | + | negative |
| | 9.iv.21* .. | Pond P | Brownish | Slightly Turbid | Nil | Neutral | ·0036 | ·0220 | ·2157 | ·25 | Present | ·01 | 5·0 | + | — |

* Samples filtered before being analysed.

clearing only on the distribution of *A. umbrosus*, as a necessary preliminary to making a study of the ultimate factors concerned in its disappearance, the writer caused the bush surrounding the pool to be partly cleared, and then, three months later, to be completely cut down. Collections were made at intervals both before and after clearing, and the results are given in the following table :—

TABLE V.

| Date. | *A. umbrosus.* | *A. barbirostris.* | *A. hyrcanus.* | *A. aconitus.* |
|---|---|---|---|---|
| 20.vii.20 .. .. .. | 113 | — | — | — |
| 23.vii.20 .. .. .. | 32 | — | — | — |
| 12.viii.20 .. .. .. | 130 | — | — | — |
| 24.viii.20 .. .. .. | 184 | — | — | — |
| 2.ix.20 .. .. .. | 193 | — | — | — |
| 6.ix.20 .. .. .. | 130 | — | — | — |
| 22.ix.20 (here bush partly cleared) .. .. .. | 11 | — | — | — |
| 10.x.20 .. .. .. | 66 | — | — | — |
| 4.xi.20 .. .. .. | 2 | 2 | 3 | — |
| 8.xii.20 .. .. .. | 10 | — | 14 | — |
| 30.xii.20 (here bush completely cleared) .. .. .. | 114 | 365 | 110 | — |
| 17.i.21 .. .. .. | 48 | 70 | — | — |
| 27.i.21 .. .. .. | — | 140 | — | — |
| 19.ii.21 .. .. .. | — | 76 | 50 | — |
| 25.ii.21 .. .. .. | — | — | — | — |
| 5.iii.21 .. .. .. | — | 28 | — | — |
| 11.iii.21 .. .. .. | — | 37 | 3 | — |
| 6.iv.21 .. .. .. | — | 24 | 2 | 1 |

Some diminution of *A. umbrosus* therefore resulted from the partial clearing ; the invasion by *A. hyrcanus* and *A. barbirostris*, which took place at the same time, was in accordance with expectation. The final disappearance of *A. umbrosus* and its replacement by the two other species when the clearing had been completed are well brought out by the figures. What can be the causes at work ?

One might be disposed to attribute the failure of the former species merely to the letting in of sunlight ; producing, perhaps by direct action, or by affecting the gas content of the water, a change of the algal flora. It was not possible to decide that these larvae died as the direct result of exposure to the sun, on account of the difficulty, which was not overcome until just before the work was terminated by leave, of keeping the larvae long alive in captivity and getting them to grow. The disappearance would hardly have been due to the fouling of the water by the vegetable matter which fell in during clearing, since the pool always received its share of the carpet of leaves elsewhere.

Whatever the causes which lead to so profound an alteration of the Anopheline fauna, they must be apparently trivial ones. Unfortunately no water was collected for analysis before clearing was effected, but in the following table is given the result of an analysis by Mr. Blair of the water subsequent to clearing and of water from another pool in secondary bush elsewhere, which afforded the larvae of *A. umbrosus* in pure culture.

TABLE VI.

*Analyses of Samples of Water.*

| Date. | Source. | Colour. | Turbidity. | Suspended Matter | Reaction. | Parts per 100,000. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Ammoniacal Nitrogen. | Albuminoid Nitrogen. | Oxygen absorbed 3 hours. | Chlorine. | Nitrites. | Oxidised Nitrogen. | Total Solids. | Iron | Sulphuretted Hydrogen. |
| 11.iii.21 (Larvae of *A. umbrosus* disappeared) | Bush Pond D cleared | Brownish green | Turbid | Some | Slightly Acid | ·0024 | ·0420 | ·5382 | ·08 | Nil | ·01 | 10·0 | + | negative |
| 11.iii.21 (Breeding-place of *A. umbrosus*) | Pool E in bush | Slightly Brownish | Slightly Turbid | Some | Neutral | ·0024 | ·0192 | ·5382 | ·15 | Nil | ·01 | 4·0 | + | negative |

When the nature of this influence determining Anopheline distribution has been ascertained, it can hardly be doubted that a method of control of the species, at once less expensive, less crude, and more scientific than the constant dumping of valuable mineral oil on to the breeding-places, will be at hand. The broad general possibility of such a method of control was long since realised by Dr. Watson, and is emphasised in his various contributions to the literature dealing with malaria and sanitation in the tropics. Thus, Dr. Watson gives a table showing the presence of the dangerous *A. maculatus*, *A. aconitus* (*albirostris*) and *A. umbrosus* at the foot of the hills forming the Bukit Gantang valley in the Malay States, and of *A. aconitus* and *A. umbrosus* in the rice-fields of the valley, and shows that neither is present in the Krian irrigation area.* He then observes: "I suggested that in the future it might be possible to eradicate malaria from certain places by altering the composition of the water in such a way as to make it uninhabitable for some particular malaria-carrying mosquito. It was therefore with the greatest interest that I found in 1913 that one of the most dangerous malaria-carrying *Anopheles* which exists had been driven from the rice-fields of British Guiana by controlling the water supply. This is one step towards what I suggested in 1910, in a public lecture, given in Kuala Lampur, in the following words: 'But when we came to work out the Anophelines, it was found that different species were found in the middle of the swamp from those on the hills. Nature has, therefore, carried out a great experiment. There were three groups of Anophelines: one on the hills, one on the rice-fields close to the hills, and a third lot in Krian far from the hills. Now why do these vary? Clearly on account of something in the water; and it can be easily imagined that only a small change would assimilate the Bukit Gantang water to that of the Krian rice-fields, and then malaria would disappear from Bukit Gantang too. I believe that in this way a great anti-malaria method will be evolved, and I can look to the time when we will be able to play with species of *Anopheles*, say to some "Go," and to others "Come," and to abolish malaria with ease, perhaps at hardly any expense. Drainage schemes may become things of the past, and future generations may smile to think how their ancestors, who thought they were so clever, burned the house to cook the pig.' "

Dr. Watson remarks further in the same book (p. 14) (as to *A. maculatus*): "I came to the conclusion that unless we could alter the composition of the water in these hill streams in such a way as to make it uncongenial to all malaria-carrying mosquitos, the only way we could get rid of the insect (and malaria) would be by putting the streams underground in pipes."

A paragraph in an unpublished report by Dr. Hacker, dated 30th July 1917, on the distribution of Anopheline larvae on a certain estate in the Federated Malay States, may be quoted here, with his kind permission, as having some bearing on Dr. Watson's contention. Discussing the suitability of a site proposed for new coolie lines, more especially as regards its proximity to breeding-places of *A. maculatus*, he remarks: "The main ravine in front of the site is also a favourable place for *maculatus*, and probably the reason that more breeding was not discovered on this visit was the amount of decaying vegetation. The grass has been cut down and allowed to rot in the sand, and whenever it was stirred up it emitted an offensive smell. When the water gets clean more breeding will probably occur."

By the courtesy of Dr. Watson the writer had the privilege of reading a portion of the manuscript of a forthcoming new edition of his book, "The Prevention of Malaria," and is permitted to quote the following paragraphs having further bearing on the subject:—

"Previously, I mentioned the appearance of a green slime on the bottom of the ravine following on the application of the oil. It consists of an alga, the filaments of which are closely felted or matted, and attached to the stones or sand forming

* "Rural Sanitation in the Tropics." 1911.

the bed of the stream. The filaments are much finer than those of the ordinary alga that one finds in a pool of clear water in a ravine ; and the felting differs from the loose floating tangle of the ordinary alga. When a clear pool containing the ordinary floating alga is oiled, the alga dies ; it becomes a dark green mass, in which the individual filaments become unrecognisable. In its place appears the felted alga, and wherever a ravine is thoroughly oiled this alga appears. It is a test by which to know if oiling is properly carried out. Long before I had used oil in ravines I had noticed that the presence of the felted alga meant the absence of *A. maculatus*, and I had noticed its association with pollution of the water. For example, on an estate there were four ravines, identical as far as the eye could see. At the head of one, there was a well where clothes were washed ; that ravine alone contained the felted alga. On no occasion was *A. maculatus* taken in it. In the other three ravines, which were not polluted and did not contain the felted alga, the insect flourished. Three bungalows, one on each of these ravines, were so malarious that they were pulled down ; a bungalow on the other ravine was much less malarious and is still inhabited. This was observed before oiling was used in ravines.

" Some ravines are to be found where the felted alga is growing freely, although no pollution apparent to the eye takes place and no oiling has been done. On one occasion I found the felted alga in a ravine and traced it upwards. The ravine branched and the alga followed only one branch, in which it could be found as far as a log of newly cut timber lying in the water. Beyond that the alga could not be found. I can give no explanation of its appearance. I took possession of a piece of the wood.

" In ravines where the pollution is extreme, where, for instance, the whole discharge from a rubber factory is poured into a small stream, the aquatic growth will be found to differ in different parts of the stream. Nearest the factory the growth may consist of dense pendulous fawn-coloured masses composed of colourless filaments, containing no chlorophyll ; lower in the ravine this is replaced by the felted alga.

" A full study of the subject is necessary, and may well give us an entire new method of controlling malaria."

Dr. Watson's views, which the writer has permission to quote, on the possibility of the control of *A. aconitus* in such a way are contained in a letter of 5th December 1920.

" With regard to *A. aconitus*, my chief reasons for thinking it does not like decomposing organic matter are epidemiological ; and, as Darling says in his paper ' On Experimental Inoculation of Malaria by means of *A. ludlowi* ' (p. 315), it is the epidemiological evidence in the last analysis which convicts a species and will determine the necessity for taking steps against it.

" The first evidence I ran against was its absence from the Krian rice-fields, which are free from malaria. The details are in my ' Prevention,'* but it is summarised at pages 21–23 in ' Rural Sanitation.'

" The next evidence is its absence from the Coastal Plains—from drains full of grass, in which at first sight one might expect it.

" Again it does not occur in the big swamps and valleys where there is mining silt. There we get *barbirostris*, *sinensis* (= *hyrcanus*), *rossi*, *fuliginosus*, from the various breeding-places ; but hardly ever *aconitus* ; and the malaria rate is low. I have used this knowledge for years and have not hesitated to house coolies on the edge of mining swamps.

" I have always felt that we could control the malaria of the valley of rice-fields by some form of pollution—perhaps by adding some decomposable manure, or by

* " The Prevention of Malaria."

ponds on the 'tali ayers' in which some cheap matter was decomposing, on the lines of the big reservoir in the Krian rice-fields."

Inasmuch as the investigations that have been discussed are at an end in the Malay States, so far as concerns the writer, it may not be out of place to indicate the directions which the enquiry would have taken, had it been resumed by him :—

1. Further data as to the distribution of *A. aconitus* would have been obtained by study limited to unit breeding-places only.

2. The study would have been extended to *A. umbrosus* with a view to ascertaining the factors on which its limitation (in the uplands) to bush pools depends, and the influences (as in the instance quoted) which brought about its disappearance on clearing.

3. The algal flora of various breeding-places would have been collected and submitted to an algologist for determination, and for information as to the conditions which determine the presence of the character plants, and enable them to flourish.

4. Full chemical analyses of waters containing the species would have been obtained, with further and fuller analyses of fishpond and other waters from which *A. aconitus* is consistently absent. In this connection Dr. A. R. Wellington, the Senior Health Officer, to whom were submitted the analyses, suggested the desirability of ascertaining the iron content, the salt content, the carbonic acid content, and the relative hardness of the various waters.

5. Extended enquiry would have been made as to the factors concerned in the entire absence of Anopheline or other Culicid larvae in certain ponds and ditches on rubber estates in the neighbourhood of Kuala Lampur. Collections there made from time to time were entirely unsuccessful, though Anopheline larvae could be obtained near by in abundance. On the assumption that some quality of the water might be prejudicial to the larvae, half-grown specimens of various species were placed in the water in the laboratory; many fed up and pupated. It was then thought possible that older larvae were able to resist influences which might destroy younger ones, and so ova of various Anophelines were placed on the water. They duly hatched, and a few larvae matured. As the water from such ponds is usually coffee-coloured, owing to the maceration of dead rubber leaves and twigs in it, strong infusions and decoctions were made and tested as to their influence on larvae. They did not die off in the medium. Algae and water animalcules were poorly represented in this water, but at one season two species of tadpoles were abundant, and various predacious insects—the larvae of Neuroptera, and some BELOSTOMIDAE were swarming. It was thought that the tadpoles at a late stage of development might prove to be carnivorous, but they refused in the laboratory to eat mosquito larvae; and it was then concluded that predacious enemies alone might account for their absence. But more probably there are at work other influences which require to be determined.

6. The effect on *A. aconitus* of the fouling of water by the products of vegetable decomposition in the laboratory would have been studied with especial reference to the influence of gases, marsh gas in particular, in solution.

7. A more directly practical line of investigation would have been the determination of the effect of decomposing vegetable matter in solution on *A. aconitus*. An attempt would have been made to cut down to the surface of the water, and to dump into it, all the coarse vegetation growing in swamp A, collecting larvae from it at intervals for determination. For the further similar treatment experimentally of other breeding-places, which do not afford such a plant growth in sufficient quantity for thoroughly fouling the water, coarse grass, or the sweepings from rubber estates (dead leaves, twigs, hoed-up weeds, etc., which are usually burnt) would have been dumped in; and in smaller breeding-places, manure from the stables which accommodate estate oxen.

It may here be remarked that, when in German East Africa, the writer noted with amazement the immense amount of vegetable material rejected in the preparation of sisal hemp. Sisal consists of the fibro-vascular bundles of the leaves, and to obtain it the leaves are passed through machinery which decorticates and washes the bundles at the same time. A constant volume of water, containing the pulped cortex, the bulk of the leaf, runs away, usually into the nearest river or swamp. Accumulations of this, which are said to contain a high percentage of acetic acid, are ill-smelling and acrid, and so, in dilution, might well prejudice or destroy Anopheline larvae directly, apart from any question of the pollution of water. An experiment in this direction was in contemplation; for the plants flourish in the Malay States, at all events in certain localities, and in the event of positive results from the experiment suggested, might well supply the means of control.

Dr. Watson has already suggested* the possibilities of such methods of control; for, in 1911, in discussing the possibility of altering the composition of water so as to make it uninhabitable by larvae, he wrote: "It is not inconceivable that an industry might be found which requires the maceration of a fibre which, while changing the composition of the waters, might also provide the inhabitants with work. The culture of flax and hemp in Italy supplies a line upon which to work."

The problem is, however, one for the solution of which it is evident that the Algologist and the Chemist must alike supplement the efforts of the Entomologist. There is already a Chemist, but until his researches are co-ordinated by the Entomologist with those of the Algologist, there will always be a factor missing in the formula.

It is the writer's pleasant duty to express his appreciation of the assistance received in the course of the work from Mr. R. W. Blair, who, though over-pressed with routine work, found time to make preliminary analyses of the waters; from Dr. A. R. Wellington, who most kindly discussed the interpretation of the analyses, making further suggestions in regard thereto; and from Dr. Malcolm Watson, whose previous work has been shown to have considerable bearing on the subject discussed. It would have been impossible, within a comparatively short time, to make an investigation such as that discussed without capable and well-trained assistants. The writer was most fortunate in having in this capacity Mr. S. Ampalavanar, the senior assistant at the Malaria Bureau, and Mr. N. Thanboo, both of whom had worked for some years under the guidance of Dr. H. P. Hacker, the officer in charge. The ready identification of thousands of larvae without further breeding was only made possible through the work of Dr. A. T. Stanton on their chaetotaxy, to which tribute must therefore be paid.

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* "The Prevention of Malaria in the F.M.S.", 1911, p. 115.

# MORDVILKO'S KEYS FOR THE DETERMINATION OF APHIDS LIVING CONTINUOUSLY OR TEMPORARILY ON GRAMINACEOUS PLANTS AND SEDGES.

[The systematic keys to the species of Aphids that attack Graminaceae, recently published by Mr. A. K. Mordvilko (Bull. Petrograd Div. Sta. Protect. Plants from Pests, iii, no. 3, 1921, 72 pp., 19 figs.) are likely to be of considerable value to students of these injurious insects, and it seemed desirable that they should be translated from Russian into English. The original keys are very lengthy, and therefore Mr. B. P. Uvarov has kindly condensed them, and they have then been translated, under his supervision, by Miss F. B. Constable, of the Imperial Bureau of Entomology. Mr. F. Laing, of the British Museum, has also kindly assisted with advice in regard to certain technical points.—*Ed.*]

## A. Subfamilies and Tribes.

1 (4). Spur of last joint of antennae more or less elongate, either considerably longer than its base, or if shorter, then only very slightly so .. Subfam. APHIDINAE (part).

2 (3). Cauda sword-shaped, elongate or short-triangular ; cornicles cylindrical or almost cylindrical, sometimes dilated in the middle or in the distal half ; 6 or 7 abdominal segments, but in apterous individuals the meso- and meta-thorax merge more or less into the abdominal segments Tribe APHIDEA (p. 26).

3 (2). Cauda club- or wart-shaped, sometimes hemispherical or not pronounced (anal tergite semicircular), but in this case the body is covered with stiff hairs ; segments of body of apterous individuals, especially 3rd thoracic and 1st abdominal, more or less distinct ; cornicles generally very short, but fairly thick, somewhat widening towards base and tube-shaped towards the top, sometimes truncate, conical or nearly dome-shaped ; last joint of rostrum without a subapical constriction Tribe CALLIPTEREA (p. 31).

4 (1). Spur of last joint of antennae considerably shorter than its base, generally only in the form of a short pointed process ; antennae seldom longer than head with thorax, often considerably shorter.

5 (8). Last joint of rostrum with a distinct subapical constriction, as though with an additional 5th joint (at end of proximal division of last joint. are two fairly noticeable lateral hairs) .. Subfam. LACHNINAE

6 (7). Sides of prothorax and abdominal segments 1–5 and 7 with fairly distinct, broad, flatly convex, light, glandular tubercles, joining with dark marginal plates, especially developed on the prothorax and 1st and 7th abdominal segments .. .. .. Tribe ANOECIEA (p. 34).

7 (6). Sides of prothorax and abdomen without glandular tubercles .. .. Tribe LACHNEA.*

8 (5). Last joint of rostrum simple, without a subapical constriction ; legs short, not visible when the strongly inflated, ovate or nearly spherical body is viewed from above ; tarsi short, generally with two joints, rarely with one, or even not separated from the tibia .. .. .. .. Subfam. PEMPHIGINAE.

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* Aphids of this tribe are not yet known on graminaceous plants.

9 (10). Dorsal groups of glands either entirely absent (in root forms and alatae)-or very feebly developed, in the form of faintly distinguishable marginal groups and partly (on dorsal abdominal segments) pleural ones, in any case, leaving almost no trace in the cuticle; antennae 5- or 6, jointed, when 5-jointed the 3rd the longest .. .. .. .. Tribe FORDEA (p. 34).

10 (9). Dorsal groups of glands more or less well pronounced; apterous viviparous ♀♀ with 5-jointed antennae, sometimes 6-jointed, more seldom 4-jointed; when 5-jointed the 3rd is not the longest.

11 (12). Marginal glandular groups on basal segments of abdomen placed between the stigmata, those on the following segments either between stigmata or below them; alate viviparous ♀♀ with the oblique veins of hind wings separated from each other at their bases, sometimes the vein nearest to base of wing feeble or evanescent; wings held in a roof-like position at rest .. .. .. Tribe SCHIZONEUREA (p. 37).

12 (11). Marginal glandular groups lying slightly above the stigmal line and not below it; alate viviparous ♀♀ with the median vein of front wings simple or with a single branch; hind wings with the oblique veins arising almost together from the longitudinal, appearing as though the longitudinal vein branches into three towards its apex .. .. .. Tribe PEMPHIGEA (p. 38).

## B. Genera and Species.

### Subfamily APHIDINAE.

### Tribe APHIDEA.

1 (28). Lateral marginal tubercles as a rule feebly developed, always absent on 1st and 7th abdominal segments; front of head narrowly or widely furrowed, sometimes from the bottom of the furrow rises a small central tubercle .. .. .. .. Subtribe MACROSIPHINA.

2 (19). Cornicles one-seventh to one-quarter the length of body, considerably exceeding cauda.

3 (4). Distinct cellular sculpture on the distal portion of the cornicles, at one-quarter to three-eighths of the length from the operculum; cauda with distinct constriction at some distance from base; on prothorax and on abdominal segments 2–5 fairly distinct marginal tubercles Genus *Sitobion*, Mordv.

Here belongs at present one species, *S. avenae*, F. (*cereale*, Kalt., *granarium*, Kirby), which lives on ears of wild and cultivated Graminaceae (Palaearctic and Nearctic).

4 (3). Cornicles without cellular sculpture on distal portion or with several irregular alveoli drawn out transversely.

5 (10). Cornicles more or less cylindrical, only slightly narrowing towards operculum; on third joint of antennae of apterous viviparous ♀♀ with the exception only of the fundatrices (in which it is absent) 1–4 secondary rhinaria .. .. .. .. .. .. .. .. Genus *Acyrthosiphon*, Mordv., subg. *Metopolophium*, Mordv.

6 (7). Spur of 6th joint of antennae almost equal in length to 3rd joint; antennae of viviparous ♀♀ not exceeding the length of the body, 5-jointed in fundatrices; 3–4 bristly hairs on sides of cauda. In the spring on the ends of shoots of roses, at the end of the summer and in the autumn under leaves of roses, and in the summer on the leaves of some graminaceous plants .. .. .. *A. dirhodum*, Walk.

7 (6). Spur of 6th joint of antennae longer than 3rd joint; antennae of viviparous ♀♀ longer than body, even in normal females attaining eleven-twelfths to eighteen-nineteenths of the body length; at side of cauda 4–6 bristly hairs.

8 (9). Body of apterous females 3 mm. and more; spur of 6th joint of antennae considerably longer than 3rd joint .. .. *A. graminearum*, Mordv.

9 (8). Body $1\frac{1}{2}$–2 mm.; insects very delicate, semi-transparent; spur of 6th joint of antennae only very slightly longer than 3rd joint .. .. *A. graminum*, Theo.

10 (5). Cornicles (brown or dark brown) strongly dilated almost in the middle.

11 (18). Antennal tubercles divergent .. .. Genus *Rhopalosiphum*, Koch.

12 (15). Apterous viviparous ♀♀ yellowish; spur of last joint of antennae almost as long as 3rd joint; 3rd joint in apterous viviparous ♀♀ without rhinaria.

13 (14). Fourth joint of antennae one-fifth to two-fifths as long again as 5th; apterous viviparous ♀♀ light sulphur-yellow or greenish-yellow; cornicles much shorter than 3rd joint of antennae (half as long in alate viviparous ♀♀). In the summer on leaves of *Phalaris arundinacea* (Mordvilko, 1911) and *Glyceria fluitans* (Boerner, 1913); Europe .. *Rh. lonicerae*, Siebold.

14 (13). Fourth joint of antennae only slightly exceeding 5th, sometimes equal to it; apterous viviparous ♀♀ cadmium-yellow, their cornicles usually longer than 3rd joint of antennae, those of alatae slightly shorter. In summer on leaves of *Elymus canadensis*, *E. virginicus* and *Dactylis glomerata*; North America .. *Rh. davisi*, sp. n. (*Rh. howardi*, Davis).

15 (12). Apterous viviparous ♀♀ dark green or pale brown; spur of last joint more or less exceeding length of 3rd joint.

16 (17). Fourth joint of antennae slightly shorter than 5th; spur of 6th $1\frac{2}{3}$–$1\frac{4}{7}$ times as long as 3rd joint; cornicles twice as long as cauda, in apterous viviparous ♀♀ almost equal in length to 3rd joint. On *Panicularia* (*Glyceria*) *nervata*; N. America .. .. *Rh. howardi*, Wilson.

17 (16). Fourth joint of antennae $1\frac{2}{5}$ times as long as 5th; spur of 6th joint $1\frac{1}{5}$ times as long as 3rd; cornicles $2\frac{1}{2}$–3 times as long as cauda, slightly shorter than 3rd joint of antennae. On roots of *Dactylis glomerata*; N. America .. .. .. .. .. *Rh. subterrans*, Wilson.

18 (11). Tubercles of antennae broad and low, their internal edges parallel, or slightly projecting inwards at the apex .. Genus *Myzus*, Pass., subgenus *Rhopalomyzus*, n.

Apterous and alate viviparous ♀♀ dark brown or brownish black; lateral tubercles on prothorax feeble or absent. On *Poa pratensis*; N. America .. .. .. .. *M. poae*, Gillette.

19 (2). Cornicles considerably shorter than cauda.

20 (21). Cornicles short, cylindrical, much longer than broad; frontal furrow distinct, especially in alate individuals .. Genus *Hayhurstia*, n.

This genus contains only one species, *H. dactylidis*, Hayhurst, living on *Dactylis glomerata* in N. America.

21 (20). Cornicles rudimentary, about as long as their basal width; body long and narrow; the species live mostly in rolled-up leaves of Graminaceae and some Caryophilaceae (*Stellaria holostea*; *Lychnis* sp.), more seldom free on leaves of Graminaceae (along central vein) .. .. Genus *Brachycolus*, Buckton.

22 (23). On 8th tergite a fairly large central finger-shaped process directed slantingly backwards and upwards. On *Hordeum*, *Triticum* and other Graminaceae ; South Russia, Transcaucasia, Turkestan .. .. *B. noxius*, Mordv.

23 (22). No process on 8th tergite.

24 (27). Antennae of apterous viviparous ♀♀ two-sevenths to one-third as long as the body ; spur of 6th joint exceeding base of that joint by one-fourth to a half ; 4th and 5th joints and base of 6th almost equal to each other.

25 (26). Antennal tubercles developed ; central frontal process as high as the antennal tubercles and separated from them by furrows ; body of apterous viviparous ♀♀ dark greyish green, dusted with greyish white. On *Agropyrum repens*, *Lolium* and some other Graminaceae ; N. and Middle Europe and Russia .. *B korotnewi*, Mordv. (1901). (= *B. stellariae*, Schout., v. d. Goot).

26 (25). No antennal tubercles (?) ; front of head broad and slightly convex ; body of apterous viviparous ♀♀ pale green to pale yellow, dusted with white. On *Agropyrum glaucum* ; N. America, Colorado .. .. *B. tritici*, Gillette (1911).

27 (24). Antennae in apterous viviparous ♀♀ almost half as long as the body ; spur of 6th joint almost twice as long as the base of that joint ; 3rd joint almost twice as long as 4th ; base of 6th joint two-thirds to four-sevenths the length of 5th joint ; body pale green or yellowish green, not pruinose. North Russia ; on leaves of *Dactylis glomerata* *B. slavae*, sp. n.

28 (1). Of the marginal tubercles those on prothorax and 1st and 7th abdominal segments are the most developed ; front of head broad and slightly convex .. .. .. .. .. Subtribe APHIDINA.

29 (52). Antennae in summer apterous viviparous ♀♀, as well as in alatae, 6-jointed (the fundatrices only of some species have 5 joints).

30 (31). Cornicles one-half to two-thirds the length of cauda ; slightly narrowed towards base ; front of head slightly convex between the low antennal tubercles ; body of apterous viviparous ♀♀ elongate ovate or fusiform, green, dusted with greyish white .. .. Genus *Hyalopterus*, Koch.

This contains only *H. pruni*, F. (= *arundinis*, F.). The primary host-plants are *Prunus domestica*, *P. spinosa*, *P. insiticia* and *P. armeniaca*, on the leaves of which the Aphids can multiply all the summer ; the secondary plant is the reed, *Phragmites communis*.

31 (30). Cornicles longer than cauda, seldom (*A. donacis*, Pass.) somewhat shorter, more or less broadened towards the base ; cauda distinct, elongate or short-triangular.

32 (37). Antennal tubercles distinct and somewhat higher than the central frontal projection ; antennae longer than half the body ; cauda well developed, but shorter than cornicles ; median vein of front wing branching only once in alate individuals .. .. .. Genus *Toxoptera*, Koch.

33 (36). Colour pale or light green with deeper green median line, cauda light green ; in apterous individuals cornicles also green, but dark at apex ; first two joints of antennae and base of 3rd light green.

34 (35). Cornicles of apterous viviparous ♀♀ almost twice as long as cauda ; third joint of antennae two-thirds longer than the 4th ; males alate. South Europe, Transcaucasia, Turkestan, N. America .. .. .. *T. graminum*, Rond.

35 (34). Cornicles of apterous viviparous ♀♀ only one-fourth longer than cauda; antennae three-fifths the length of body, the 3rd joint exceeding 4th by one-third to one-quarter; males apterous. Found as yet only in the Pskov province, on leaves of *Calamogrostis* sp. .. .. .. *T. jaroslavi*, sp. n.

36 (33). Colour dark brown; cornicles black; cauda brown; antennae brown, first two joints black. On *Scirpus*; Italy .. *T. scirpi*, Pass.

37 (32). Antennal tubercles inconspicuous; front between base of antennae broad and convex, or else from the bottom of the frontal furrow there springs a central frontal tubercle, which is scarcely lower than the antennal tubercles; median vein branching twice in alate individuals.

38 (58). Cornicles more or less cylindrical, without distinct constriction before the operculum; operculum narrower than central portion of cornicle .. Genus *Aphis*, L.

39 (48). Three stout marginal tubercles: on prothorax, and on 1st and 7th abdominal segments; cornicles more or less exceeding the length of cauda.

40 (47). Spur of 6th joint of antennae at least 2½–3 times as long as the base of the same joint, 5th joint considerably (one-half to four-fifths) longer than base of 6th joint

41 (42). Spur of 6th joint subequal to 3rd joint and nearly three times as long as the base of that joint; body of apterous viviparous ♀♀ greenish brown, coffee-brown, or dull black, dusted with black .. .. .. .. *A. rumicis*, L. (= *papaveris*, F.).

This species lives on the ends of young shoots and under the leaves of the spindle-tree, white hazel tree and jasmine (primary hosts), and on many herbs (intermediate hosts): *Rumex*, *Atriplex*, *Chenopodium*, *Beta*, *Rhoeum*, *Lappa major*, *Vicia faba* and others; of the Graminaceae only on maize.

42 (41). Spur of 6th joint of antennae 1–2 times as long as the 3rd joint, and 3–6 times as long as the base of that joint.

43 (44). Body of apterous individuals yellowish or yellowish-green. On *Sorghum*; West Africa (Togo) .. .. .. .. *A. sorghella*, Schout.

44 (43). Body of apterous individuals brown.

45 (46). Body and legs covered with fairly long hairs; on the segments of the body (at least in apterous individuals) hairs arranged in transverse rows, each hair arising from an elevated base; spur of 6th joint of antennae 3½–4½ times as long as the base of that joint and 1⅗–2 times as long as 3rd joint. On *Carex pseudocyperus* and others; Belgium *A. caricis*, Schout.

46 (45). Body and legs not very hairy; hairs on body arising from the smooth surface; spur of 6th joint of antennae 5–6 times as long as the base of that joint, and twice, or nearly twice, the length of 3rd joint. On *Prunus maritima* and *Setaria*; N. America *A. setariae*, Thomas.

47 (40). Spur of 6th joint of antennae not more than twice as long as the base of the same joint; 5th joint subequal to the base of 6th or even somewhat shorter. N. America; on roots of *Sorghum*, *Setaria*, *Panicum*, *Rumex*, *Polygonum*, *Portulaca*, *Brassica nigra*, *Plantago major*, pumpkin and others .. .. .. .. .. .. *A. maidi-radicis*, Forbes.

48 (39). Three pairs of small marginal tubercles: on the prothorax and on 1st and 7th segments of abdomen; body of apterous viviparous ♀♀ 2–2½ times as long as wide.

49 (50). Cornicles longer than cauda ; body of apterous viviparous ♀♀ dull green or whitish green, but front part of head generally dark tawny, and brown tranverse lines on 8th (and sometimes 7th) abdominal segment. In partly curled upper leaves of *Panicum crus-galli*, *Sorghum*, *Hordeum*. etc., but sometimes on the ears and external surface of leaves.. .. *A. maidis*, Fitch (= *avenae*, Kalt., nec F., nec Mordv.).

50 (49). Cornicles not longer than cauda ; body brownish, covered in places with white dust, owing to which the living Aphids have a variegated appearance. On leaves of *Arundo donax* ; S. Europe (Italy, Transcaucasia) *A. donacis*, Pass.

51 (38). Cornicles distinctly constricted before the operculum ; operculum broad, as wide as or wider than the middle of the cornicle .. .. .. Genus *Siphonaphis*, v. d. Goot.

Body of apterous viviparous ♀♀ green with reddish brown spots at the base of cornicles, broadly ovate, its width slightly more than half the length. On leaves and flowering parts of various Graminaceae ; Palaearctic (in connection with distribution of *Prunus padus*) and N. America .. .. .. .. .. .. .. exules of *S. padi*, L. (= *avenae*, Mordv., Perg., Davis, Theo., Patch., etc., *nec* Fabr.).

Two subspecies may be recognised in the case of the exules.

*(**). Spur of last joint of antennae $1\frac{1}{7}$–$1\frac{1}{2}$ times as long as the 3rd joint (in alate sexuparae almost equal to it or slightly longer or shorter). Palaearctic .. .. .. *S. padi padi*, L.

**(*). Spur of last joint of antennae about $1\frac{2}{3}$ times as long as the 3rd joint (in alate sexuparae $1\frac{1}{3}$–$1\frac{2}{5}$ times). N. America .. *S. padi americana*, subsp. n. (= *Siphocoryne avenae*, Perg., and other American authors).*

Also in the fundatrigeniae :—

*(**). Spur of 6th joint of antennae shorter than 3rd joint, seldom almost equal to it (more often in alate viviparous ♀♀) .. *S. padi padi*, L.

**(*). Spur of 6th joint of antennae longer than 3rd joint .. .. *S. padi americana*, subsp. n.

52 (29). Antennae 5-jointed, short, about half the length of body, at least in apterous viviparous ♀♀.

53 (54). Cornicles very short, shorter than cauda, almost cylindrical, narrowing slightly towards the operculum, which is slightly broader than the penultimate portion of cornicle ; cauda elongate, thicker in the middle than the middle portion of cornicles ; of the marginal tubercles only those on prothorax and 7th abdominal segment fairly distinct .. Genus *Geoktapia*, n.

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* If "*Siphocoryne*" *splendens*, Theo., found in Egypt (Gizeh, 18.ii.08) on wheat, is near to *Aphis padi*, L., owing to the structure of the cornicles and other characters it is in any case distinguished by having fairly long hairs on the antennae and legs (in *A. padi* the hairs on the 3rd joint of the antennae hardly exceed half the diameter of the joint, whereas in "*Siphocoryne*" *splendens*, to judge by Theobald's illustration, they are at least equal to the diameter ; besides this, the cornicles in *A. padi* are decidedly shorter than the 3rd joint of the antennae, while in *S. splendens* they are longer (cf. F. V. Theobald, 1915).

Body of apterous viviparous ♀♀ elongate, 2–2⅗ times as long as broad; antennae about half the length of body; spur of last joint 3–3½ times as long as base of the same joint; hairs on antennae very short, scarcely perceptible; body dark, with dark waxy covering. In slightly rolled leaves of couch grass and possibly other graminaceous plants; East Transcaucasia .. .. .. .. *G. areshensis*, sp. n.

54 (53). Cornicles at least twice as long as cauda.

55 (56). Cornicles only twice as long as cauda, with middle portion slightly thicker than middle portion of cauda; spur of last joint of antennae 4–5 times as long as base of that joint; body of apterous viviparous ♀♀ broadly ovate; marginal tubercles present on prothorax and 1st and 7th abdominal segments, those on prothorax the largest.. .. .. Genus *Aresha*, n.

Body of apterous viviparous ♀♀ yellowish brown or dark brown, sometimes with an admixture of green, almost dull or else with a very faint greasy shine, scarcely dusted; antennae, legs, cornicles and cauda brown; antennae about half the length of body or shorter; spur of last joint 4–5 times as long as base of that joint and 1⅔ times as long as 3rd joint; hairs of antennae bristly, thin and long, the larger ones of the 3rd joint almost twice as long as the diameter of the joint. Elisavetpol province; on roots of rice .. .. .. *A. shelkovnikovi*, sp. n.

56 (55). Cornicles 4–6 times as long as cauda, dilated in the middle .. .. Genus *Carolinaea*, Wilson.

In apterous viviparous ♀♀ the spur of last (5th) joint of antennae only slightly longer than the base of that joint; antennae shorter than half the length of body; body smooth, greenish yellow, shaded with brown. N. America; on *Carex* sp., growing in marshes .. .. *C. caricis*, Wilson.

## Tribe Callipterea.

1 (20). Antennae of apterous and alate viviparous ♀♀ 5-jointed, short, not longer than head with thorax; stiff or needle-like hairs all over body .. Genus *Sipha*, Pass.

2 (3). Skin on body covered with small spinules, hairs arising from thin tubercles *Sipha glyceriae*, Kalt. (= *schoutedeni*, Guerc.).

3 (2). Skin almost smooth, without spinules.

4 (7). Cauda distinct, constricted at base.

5 (6). Spur of last joint almost twice as long as basal width of the joint and subequal to 3rd joint; apterous viviparous ♀♀ canary-yellow. N. America; on leaves of *Panicum sanguinale* and cultivated Graminaceae *S. flava*, Forbes.

6 (5). Spur of the last joint somewhat shorter than basal width of same joint and almost one-third the length of 3rd joint; apterous viviparous ♀♀ at first rusty-yellow, but later on becoming dark brown with a median line; body covered with grey hairs and whitish dust (in alatae). N. America, Colorado; on upper surface of leaves of *Agropyrum glaucum* *S. agropyronensis*, Gillette.

7 (4). Cauda not developed.

8 (19). Hairs narrowing towards the tip.

9 (18). Last joint of rostrum not more than $1\frac{1}{2}$ times as long as penultimate joint.

10 (13). Hairs on body short, mostly thick ; hairs on front of head at sides from 0·06 to 0·08 mm., about two-sevenths to one-fifth of width of head immediately in front of the eyes.

11 (12). Second joint of antennae in apterous females equal to one-sixth to one-fifth of length of 3rd joint ; 4th joint almost equal to base of 5th ; body dark brown, shining .. .. .. .. .. .. ..
*S. maidis*, Pass. (= *elegans*, Guerc. ; *maidis avenae*, Guerc. ; *? graminis*, Kalt.).

12 (11). Second joint of antennae in apterous females equal to two-ninths to two-sevenths of length of 3rd joint ; 4th joint somewhat shorter than base of 5th, equal to three-quarters to five-sevenths of its length ; spur of 5th joint $1\frac{1}{2}$–$1\frac{1}{3}$ times as long as base of that joint ; antennae one-third to one-half length of body ; body green and dark green. Stavropol province ; on *Panicum miliaceum* .. .. *S. uvarovi*, sp. n

13 (10). Hairs thin, fairly long ; those on front of head 0·11 to 0·12 mm. long, equal to about two-fifths to three-sevenths of width of head immediately in front of compound eyes.

14 (15). Fourth joint of antennae in apterous viviparous ♀♀ equal or almost equal to base of 5th ; 2nd joint of antennae one-quarter to one-third the length of 3rd ; hairs on body thick ; body green or yellow .. ..
*S. kurdjumovi*, sp. n.

15 (14). Fourth joint of antennae in apterous viviparous ♀♀ $1\frac{2}{5}$–$1\frac{1}{4}$ times as long as base of 5th ; 3rd joint longer than the whole of the 5th ; hairs on body thin, long.

16 (17). Spur of 5th joint less than twice as long as the base of that joint ; last joint of rostrum subequal to the penultimate ; colour of apterous viviparous ♀♀ greenish yellow, yellowish green, brown or dark yellow with a distinct pale median line ; fairly large Aphids, 2–2·39 mm. in length. On leaves of *Elymus arenarius* ; Petrograd, Orenburg ..
*S. arenarii*, sp. n.

17 (16). Spur of 5th joint twice or nearly twice as long as the base of that joint ; last joint of rostrum $1\frac{1}{2}$ times as long as the penultimate ; apterous individuals green, without a pale median line ; small Aphids 1·63–0·75 mm. On *Juncus lamprocarpus* .. *S. italica*, Guerc.

18 (9). Last joint of rostrum more than twice as long as the penultimate, stiletto-shaped .. .. .. .. .. .. *S. berlesei*, Guerc.

19 (8). Hairs on body flattened and broadened apically ; body of apterous viviparous ♀♀ narrow and long, its width about two-fifths of its length. Bessarabia .. .. .. .. .. *S. tshernavini*, sp. n.

20 (1). Antennae 6-jointed, one-half to two-thirds the length of body or even longer than it.

21 (30). Antennae shorter than body, about one-half to two-thirds of its length.

22 (29). Dorsal surface of body not covered with tubercles ; spur of last joint of antennae shorter than base of joint ; in living individuals antennae directed forwards. On leaves of sedge (*Carex*) .. .. .. ..
Genus *Allaphis*, Mordv. (= *Callaphis*, Mordv., 1908 ; *Tripsaphis*, Gillette, 1917).

23 (26). Anal sternite fairly deeply emarginate behind in the middle; on dorsal surface of body rows of grouped glandular pores, secreting a delicate waxy down (in spirit specimens, groups of light pores visible); skin of body and antennae more or less smooth, not covered with spinules; on 3rd joint of antennae small hairs; hairs on the hind part of body delicate, bent .. .. .. .. .. .. *A. caricis*, Mordv.

24 (25). Antennae of apterous viviparous ♀♀ five-sevenths the length of body; spur of 6th joint equal to two-thirds of length of basal portion of that joint. At Belovej and Petrograd on *Carex* sp., and in Jaroslav province on *Juncus* sp. .. .. .. *A. caricis caricis*, Mordv.

25 (24). Antennae of apterous viviparous ♀♀ about half the length of body, even in the alatae slightly less than three-quarters the length of body; spur of 6th joint only slightly shorter than base of same joint, equal to six-sevenths to nine-tenths of its length. On the island Langr at mouth of Amur River .. *A. caricis amurensis*, subsp. n. (= *Brachycolus balli*, Gillette, 1908; on *Carex* sp., N. America, Colorado).

26 (23). Anal sternite only faintly emarginate behind in the middle; no pale glandular pores on dorsal surface of body; skin with spinules like shagreen; small spinules on joints of antennae arranged in dense transverse rows; hairs on the hind part of body bristly; no hairs visible on 3rd joint of antennae .. .. .. *A. caricicola*, Mordv., 1908.

27 (28). Antennae about half the length of body; spur of last joint almost one-third of the 3rd. On sedges; Europe .. .. .. .. .. *A. caricicola caricicola*, Mordv.

28 (27). Antennae about one-third the length of body; spur of last joint about half the 3rd joint. On *Carex nebraskensis*; N. America, Colorado .. *A. caricicola verrucosa*, Gillette, 1917.

29 (22). Dorsal surface of body of apterous individuals covered with four rows of tubercles bearing hairs; spur of last joint of antennae not shorter than base .. .. .. .. .. Genus *Myzocallis*, Pass.

Body of apterous viviparous ♀♀ green, tubercles on body black; antennae two-thirds the length of body, last two joints black; base of femora, tibiae and tarsi black. Under leaves of *Cyperus rotundus*; South Italy .. .. .. .. .. .. *M. cyperus*, Macchiati.

30 (21). Antennae longer than body, or at least of the same length.

31 (32). Head elongato-rectangular; front of head between base of antennae almost straight; eyes remote from base of antennae; hairs on body spatulate or fan-shaped at tip .. .. Genus *Saltusaphis*, Theo.

*a* (*b*). Body elongate, yellowish; on the head a dark median line and two lateral ones from base of antennae to eyes; antennae in apterous individuals blackened from the middle of the 3rd joint to the end; cornicles dark. On *Scirpus*; Egypt, Gezireh .. *S. scirpus*, Theo.

*b* (*a*). On *Carex* sp.; N. America, Colorado .. .. .. .. .. .. *S. flabella*, Sanb., Gillette (1909, 1917).

32 (31). Head of the usual form, scarcely longer than broad, or even shorter; eyes not far from base of antennae; antennae longer than body .. Genus *Callipterus*, Koch.

Antennae $1\frac{2}{5}$ times as long as the body; 3rd joint $1\frac{1}{2}$–2 times as long as 4th; 4th slightly shorter than 5th; base and spur of 6th joint almost equal to each other; cauda wart-shaped; apterous individuals lemon-yellow to dark yellow. N. America, California; on lower surface of leaves of bamboo (*Arundo* sp.) .. .. *C. arundicolens*, Clarke.

## Subfamily LACHNINAE.

### Tribe ANOECIEA.

In this tribe there is as yet only one genus, *Anoecia*, Koch.

1 (4). In apterous viviparous females from roots, 6th joint of antennae $1\frac{1}{3}$ times as long as 5th, the spur being equal to more than one-third or almost one-third of base.

2 (3). Third joint $2\frac{2}{5}$–$2\frac{3}{4}$ times as long as 4th; eyes with numerous facets; apterous viviparous ♀♀ greenish or greenish-yellowish-white, older ones with a large dark spot on abdominal segments 2–6; in alate viviparous ♀♀ abdomen on the upper side ashen-white with a dark spot. On roots of Graminaceae live only migrantes (viviparous ♀♀), but primary host-plants are certain species of *Cornus* (*C. sanguinea, alba, sibirica* and others, but not *C. mas*) .. .. *A. corni*, Fabr.

3 (2). Third joint of antennae more than three times as long as 4th; apterous individuals pale green, more seldom olive; in alatae abdomen pale green with a dark brown spot in centre. On roots of wheat; Egypt: Gizeh .. .. .. .. .. .. .. *A. willcocksi*, Theo.

4 (1). In apterous viviparous ♀♀ from roots, 6th joint of antennae not longer than 5th, the spur being equal to about one-fifth of base; 3rd joint of antennae 3–$3\frac{1}{6}$ times as long as 4th; whitish or greyish green. On roots of Graminaceae (and sedges ?) viviparous ♀♀ and apterous sexuales, the normal females hardly differing in size from the viviparous, but having on the sides of 6th and 7th abdominal segments (both ventrally and dorsally) large groups of glands, secreting short down. Pskov province .. .. .. .. .. .. *A. pskovica*, sp. n.

## Subfamily PEMPHIGINAE.

### Tribe FORDEA.

1 (4). Rostrum very long, almost as long as body or rather shorter, its last joint in form of a long spur, which is considerably longer than 2nd joint, and $2\frac{1}{2}$–$3\frac{1}{2}$ times as long as 3rd joint; antennae long; 5th joint longer than 3rd; hairs on body of two kinds, thick and thin; anal tergite not entirely covering anus, which appears as a tranverse slit, occupying a dorsal position; apterous individuals white or whitish; alatae not known. On plant roots in ant and termite nests .. .. .. Subtribe RECTINASINA.

Here belongs one genus *Rectinasus*, Theo.

2 (3). Fourth joint of antennae $1\frac{5}{9}$–$1\frac{3}{4}$ times as long as 2nd; 2nd somewhat longer than 1st. In termite nests; Algiers .. *R. buxtoni*, Theo.

3 (2). Fourth joint of antennae only $1\frac{1}{7}$–$1\frac{1}{3}$ times as long as 2nd, which is subequal to the 1st. In ant nests, under stones; Elisavetpol province, Boz-Dag .. .. .. .. .. *R. caucasicus*, sp. n.

4 (1). Rostrum hardly extending further than the base or the middle of abdomen, its last joint being considerably shorter than 2nd and not much different in length from the penultimate; on body hairs only of one kind, thin, sometimes squamose; 3rd joint of antennae the longest; anal tergite covering anus from above .. .. .. Subtribe FORDINA.

5 (30). Hairs on body and legs of usual type, bristly.

6 (13). Body of apterous viviparous ♀♀ yellowish white or pale white, broadly oval or oval, inflated, its width equal to five-ninths to two-thirds of the length; antennae two-sevenths to one-third the length of body, usually 6-jointed; hind legs about one-half to two-thirds the length of body .. .. .. .. .. Group PARACLETINI.

7 (10). Hairs on body little noticeable, only antennae and legs hairy; hind legs about half length of body; hind tarsus two-ninths to one-quarter the length of tibia, but its first joint equal to about one-quarter length of 2nd .. .. .. .. .. .. Genus *Paracletus*, Heyd.

8 (9). Eyes in apterous viviparous ♀♀ with numerous facets; body surface with minute alveolar sculpture; hairs short, on 3rd joint of antennae about one-third to two-fifths the diameter of that joint, and on hind tibia only one-third to one-quarter the diameter of tibia; hind femora and tibiae thick, thickness of femur 0·14–0·16 mm.; body fairly inflated, length 3–3·9 mm. South Europe, Crimea, Transcaucasia, Turkestan .. .. .. .. .. *P. portshinskyi*, sp. n.

9 (8). Eyes of apterous viviparous ♀♀ with three facets; body with fine spinules, especially on fore part; hairs fairly long, on 3rd joint of antennae subequal to diameter of that joint, and on hind tibia one-half to five eighths of its diameter; hind legs more slender, femora only about 0·10 mm. in diameter; length of body, 2·67–3 mm. Central Europe, Poland .. .. .. .. .. *P. cimiciformis*, Heyd.

10 (7). Body and legs hairy, hairs fairly dense.

11 (12). Legs relatively short, hind ones differing little from middle ones; 3rd joint of antennae longer than 4th and 5th together; antennae about half length of body; rostrum fairly short, not reaching beyond first pair of legs .. .. .. .. .. Genus *Schoutedenia*, n.

Here belongs so far one species, living on roots of *Cyperus*. Belgium *S. cyperi*, Schout.

12 (11). Hind legs longer than middle ones, about two-thirds to five-sevenths the length of body, not thick, hind tibiae somewhat bent; hind tarsi long, about two-sevenths the length of tibia or somewhat shorter, almost 1½ times as long as the middle ones, and their 1st joint equal to about one-seventh to one-sixth length of 2nd .. .. .. Genus *Hemitrama*, n.

Here belongs one species, found in Transcaucasia on roots of *Setaria* and other Graminaceae. Third joint of antennae almost equal to the two last together; skin with small denticles and spinules, especially on front of body; hairs on 3rd joint of antennae almost as long as half the diameter of this joint; eyes with three facets: length 2·70–2·75 mm. .. .. .. *H. bykovi*, sp. n.

13 (6). Body of apterous viviparous ♀♀ lemon-, orange-, or ochre-yellow, or else white or pale green or greenish; ovally inflated, with fairly short legs; antennae 5-jointed .. .. .. .. Group FORDINI.

Here belongs one genus *Forda*, Heyd.*

14 (15). Third joint of antennae of apterous viviparous ♀♀ distinctly longer than 4th and 5th together; 4th joint almost equal to 5th; antennae in apterous viviparous ♀♀ one-third to three-sevenths the length of body *F. formicaria*, Heyd. (= ? *Tychea amycli*, Koch, = ? *F. occidentalis*, Hart).

* T. D. A. Cockerell has described from Colorado (N. America) several species of *Forda*, found in ants' nests (Psyche, x, 1903, pp. 216–218), but the descriptions are insufficient to enable the species to be included in this key.

15 (14). Third joint somewhat shorter than or almost equal to 4th and 5th together; 4th joint shorter than 5th; antennae of apterous viviparous ♀♀ only one-fifth to two-sevenths the length of body, but sometimes almost one-third.

16 (17). Body and extremities hairy; hairs on 3rd joint of antennae as long as from half to almost the whole diameter of that joint and even somewhat more; 4th joint almost equal to 2nd; antennae one-quarter to one-third the length of body; colour yellowish green or whitish green, dull. On roots of Graminaceae live only migrantes; in May–June appear the alate sexuparae, which migrate to stems and branches of *Pistacia*; South Europe, Transcaucasia, Asia Minor, Turkestan.* *F.* (*Pemphigella*) *follicularia*, Pass.

17 (16). Hairs very short and sparse, little noticeable or not noticeable either on body or limbs; hairs on 3rd joint of antennae as long as one-seventh to one-third of its diameter, but sometimes one-half to two-thirds of this diameter, in the latter case 4th joint distinctly longer than 2nd; antennae of apterous viviparous ♀♀ one-fifth to two-sevenths the length of body.

18 (23). Fourth joint of antennae of apterous viviparous ♀♀ distinctly longer than 2nd.

19 (22). Hairs on antennae scarcely noticeable, equal only to one-seventh to one-sixth the diameter of 3rd joint; 2nd joint of antennae two-fifths the length of 3rd.

20 (21). Eyes in apterous viviparous ♀♀ with numerous facets; anal sternite hardly projecting behind the tergite; antennae in apterous viviparous ♀♀ about two-ninths to one-quarter the length of body (in alatae about three-eighths), their 3rd joint slightly less than twice as long as 4th *F. marginata*, Koch.

21 (20). Eyes of apterous viviparous ♀♀ with three facets; anal sternite slightly projecting behind the tergite; 3rd joint of antennae twice as long as 4th .. .. .. .. .. *F. proximalis*, sp. n.

22 (19). Hairs on 3rd joint of antennae one-half to two-thirds diameter of joint; 3rd joint almost $1\frac{1}{2}$ times as long as 4th; hind legs (femora and tibiae) about half length of body; 1st joint of tarsi about one-quarter length of 2nd; anal sternite only slightly receding behind the tergite .. *F. mokrzeckyi*, sp. n.

23 (18). Fourth joint of antennae in apterous viviparous ♀♀ almost equal to 2nd; eyes with three facets.

24 (25). First joint of hind tarsus in apterous viviparous ♀♀ almost half as long as 2nd; hind legs (femur and tibia) almost one-third length of body, the tarsus about quarter length of tibia .. .. *F. trivialis*, Pass.†

25 (24). First joint of hind tarsus half as long as 2nd; tarsus one-third to three-sevenths length of tibia.

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* In southern France and Italy several species of *Pemphigella*, Tullgren, 1909, have been described as producing galls on *Pistacia*. In Transcaucasia and Turkestan so far only two species have been observed: *P. follicularia*, Pass., and *P. utricularia*, Derbes. But in the remaining forms, with the exception of *P. follicularia*, migrantes have not been bred on roots of plants. J. Lichtenstein found that *Aploneura lentisci* migrates to roots of Graminaceae (*Hordeum vulgare*, *Bromus mollis*), but he did not give a description of the apterous viviparous ♀♀ which develop there (C.R. Acad. Sc. Paris, lxxxvii, 1878, pp. 782–783).

† In the relative lengths of the joints of the antennae this species resembles *F. kingi*, Ckll. (Psyche, 1903); but in the latter the body is dark greyish to green, the whole body and extremities seldom hairy, but the cauda with hairs. N. America (Colorado); on roots of Graminaceae in ants' nests.

26 (27). Third joint of antennae in apterous viviparous ♀♀ almost twice as long as 4th; hairs on this joint equal to one-quarter to one-third of its diameter; hind tarsus one-third length of tibia; hind legs three-sevenths length of body; skin spinulose in front half of body; colour yellow.. .. *F. polonica*, sp. n.

27 (26). Third joint of antennae $2\frac{1}{4}$–$2\frac{1}{2}$ times as long as 4th; hairs on antennae hardly noticeable.

28 (29). Tarsi of hind legs one-third to two-fifths length of tibia; hind legs two-sevenths to three-tenths length of body; hairs on legs not noticeable; colour greenish .. .. .. .. *F. pskovensis*, sp. n.

29 (28). Tarsi of hind legs two-sevenths length of tibia; hind legs three-eighths length of body; hairs on hind tibiae as long as one-quarter to three-eighths diameter of tibia; dark transverse fasciae on 7th and 8th abdominal segments. N. America .. .. *F. wilsoni*, sp. n.

30 (5). Hairs on body and extremities of apterous viviparous ♀♀ squamiform, arising from brown dots .. .. .. .. Group Geoicini.

Here belongs one genus, *Geoica*, Forbes, with the species *G. squamosa*, Forbes.

## Tribe Schizóneurea.

1 (6). In apterous viviparous ♀♀ tarsus fairly distinctly separated from tibia; antennae in viviparous ♀♀ from roots usually 5-jointed (in fundatrices 4- and 3-jointed), the longest joint being not the 3rd but the 4th; anal sternite projecting behind the tergite and bearing on both sides several long hairs bent inwards, to which in living Aphids small drops of excrement adhere; in alate viviparous ♀♀ 3rd joint of antennae shorter than the last three together; median vein of front wings simple .. Genus *Tetraneura*, Hart. (*Amycla*, Koch, *Pemphigus*, Pass., *partim*).

2 (5). In apterous viviparous ♀♀ with 5-jointed antennae, the last three joints almost equal in length or else the 4th longer than the others; sometimes antennae 6-jointed; in alate viviparous ♀♀ 3rd joint distinctly shorter than the three apical ones together.

3 (4). In apterous viviparous ♀♀ with 5-jointed antennae, 4th joint the longest, 3rd and 5th almost equal in length, or else 3rd slightly longer than 5th; in individuals with 6-jointed antennae (which arise in consequence of the division of the 3rd joint into two) first three joints more or less of equal length, 4th the shortest, and 5th the longest, 6th about five-ninths of 5th; at sides of body hairs very small, hardly visible, only on abdominal segments 6–8 do they reach 0·024–0·060 mm.; anal tergite short and covering only a small portion of the sternite; on both sides of anal sternite three long hairs, 0·11–0·13 mm. long; in alate sexuparae 3rd joint of antennae $1\frac{2}{9}$–$1\frac{1}{2}$ times as long as 5th, 5th almost twice as long as 6th, which is almost equal to 4th.. .. *T. ulmi*, DeGeer (*Amycla fuscifrons*, Koch, *Pemph. zeae-maydis*, Duf., *boyeri*, Pass., *caerulescens*, Mordv., *Tetr. setariae*, Guerc., *Byrsocrypta graminis*, Schout., *Tetr. ulmisacculi*, Patch, *T. yezoensis*, Matsumura, 1917).

4 (3). In apterous viviparous ♀♀ with 5-jointed antennae, the last three joints almost equal to each other; or even 4th somewhat shorter than 5th; at sides of body hairs fairly long, measuring 0·106–0·10 mm. on 7th and 8th abdominal segments; anal sternite strongly projecting backwards and with only two inwardly bent hairs on each side, measuring

0·072 mm. ; in alate sexuparae 3rd joint of antennae $2\frac{1}{5}$–$2\frac{1}{3}$ times as long as 6th and almost twice as long as 5th, 4th joint somewhat shorter than 6th .. .. *T. rubra*, Licht. (*P. coerulescens*, Pass., *boyeri*, Mordv.).

5 (2). In apterous viviparous ♀♀ antennae very short, 5-jointed, the 3rd being the shortest, and 5th longest ; in alate viviparous ♀♀ 3rd joint almost equal to three others taken together. N. America .. .. .. *T. graminis*, Monell.

6 (1). In apterous viviparous ♀♀ tarsus not at all or hardly separated from tibia ; antennae very short, 4-jointed, 3rd joint somewhat longer than the others ; anal tergite and sternite equally small and not projecting backwards ; in alate viviparous ♀♀ 3rd joint of antennae equal to three-quarters to twelve-thirteenths the length of the three remaining taken together, the last three joints being almost equal in length ; median vein of fore wing branching once ; comparatively small species, up to $1\frac{1}{2}$ mm. Migrantes on sedge roots (*Carex*), but in N. America on *Eragrostis minor* and *Panicum* ; partly hibernating on roots .. .. .. .. .. Genus *Colopha*, Monell.

Here belongs only one species, *C. compressa*, Koch, 1857 (*ulmicola*, Fitch, 1859), in which the fundatrices and alate virgines-emigrantes develop in red depressed galls between the veins of leaves of *Ulmus effusa* in the Palaearctic and *U. racemosa* in the Nearctic region.

## Tribe Pemphigea.

Of this tribe several species live on roots of Graminaceae, apparently as migrantes, but their connection with other species on primary host-plants has not yet been completely established. The species in most cases have been insufficiently characterised by previous authors, and often to such an extent that with some species there is no certainty that they do not belong to another tribe.

The root Aphids of the tribe Pemphigea so far known from Graminaceae, including the insufficiently characterised ones, may be provisionally distinguished by the following key :—

1 (14). Antennae 5-jointed in apterous viviparous ♀♀ from roots.

2 (3). All joints of short antennae almost equal in length, last joint thicker ; body bristly, white-marmorated, powdered .. .. .. .. *Tychea setulosa*, Pass. (*nec* Buckton, = *Endeis pellucida*, Buckt.).

3 (2). Joints of antennae not equal to each other, either 5th or 3rd longer than the others.

4 (13). Fifth joint longer than the others or at least not shorter than 3rd.

5 (8). First four joints of antennae more or less equal to each other.

6 (7). Body oval, pale ochre yellow ; on dorsal surface of body well-developed groups of glands, from which is secreted a white down. On roots of *Poa annua* ; South England .. .. *Rhizobius poae*, Buckt.

7 (6). Body spherical, smooth, yellowish white, slightly powdered ; last three joints of antennae more or less equal in length. On roots of *Carex dioica* ; South England .. .. .. *Endeis formicina*, Buckt.

8 (5). First four joints of antennae not equal to each other.

9 (10) Third joint of antennae almost equal to 5th, others considerably shorter than they ; four longitudinal rows of grouped glands, better pronounced on the hind part of abdomen.* On roots of *Panicum proliferum* and *P. glabrum* ; N. America .. .. .. *Rhizobius spicatus*, Forbes.

10 (9). Fifth joint of antennae longer than 3rd.

11 (12). Third joint of antennae distinctly longer than 2nd and 4th, although shorter than the others, only slightly shorter than 1st joint or subequal to it ; tibiae somewhat longer than femora ; hairs on body and extremities not noticeable .. .. .. .. .. .. .. *Tychea eragrostidis*, Pass., Buckt.† (= *Tychea brevicornis*, Forbes).

12 (11). Third joint of antennae somewhat shorter than 2nd and even the 1st, but sometimes almost equal to 1st ; 4th joint considerably shorter than the rest, almost half of the 2nd ; tibiae somewhat shorter than femora ; only the marginal groups of glands clearly visible, the pleural ones may also be partly perceptible (*Pemphigella* ? p. 19, footnote) .. *Tychea sylvestrii*, sp. n.‡

13 (4). Third joint of antennae longer than the others ; body whitish yellow, with an admixture of meat-red or pink. In ants' nests and on roots of *Avena pratensis* ; South England, Belgium .. *Endeis carnosa*, Buckt.

14 (1). Antennae 6-jointed in apterous viviparous ♀♀ from roots.

15 (16). Antennae short, 3rd joint the shortest, not more than half of 2nd ; last three joints almost equal to each other. On roots of *Poa annua* ; N America .. .. .. .. .. *Rhizobius poae*, Thomas.

16 (15). Antennae one-quarter the length of body ; 3rd joint somewhat longer than the others, but shorter than 1st and 2nd together ; 4th joint somewhat shorter than 5th, and the latter almost equal to basal portion of 6th ; colour dirty white ; on dorsal surface six longitudinal rows of grouped glands ; length of body 2·2 mm. On roots of Graminaceae and possibly other plants ; N. America .. .. .. .. .. "*Trama*" *erigeronensis*, Thomas.

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* The disposition of the glands (from above only four longitudinal rows are visible, and not all six) suggests that this species may belong to the tribe SCHIZONEUREA. The settlement of this question is impossible without a more detailed description of the groups of glands.

† It may be that the N. American species (Colorado) from ant nests, *Tychea lasii*, Ckll., and *crassa*, Ckll. (Psyche, 1903) are closely related to this species.

‡ *T. pallidula*, Cockerell (Psyche, 1903) from N. America, in which the 3rd joint is longer than 1st, is distinct from this species.

# ON THE CHALCIDOID PARASITES OF PSYLLIDS (HEMIPTERA, HOMOPTERA).

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While engaged in working out some small lots of Psyllid parasites from various parts of the world, I have found it necessary to examine, as far as possible, the records of Chalcids which up to the present have been bred from these hosts. The literature has proved to be more extensive than had been anticipated, and it has therefore seemed well to bring together and list these scattered references when describing the forms that have been considered as new.

1. *Similarity of Coccid and Psyllid Parasites*.—In the following summary are noted 18 species belonging to the families Encyrtidae (14) and Eulophidae (4). Of the eight genera containing these species four at least include others which attack Coccids. In one instance indeed (*T. sicarius*, Silv.) the same species of parasite has been reared from hosts of both families (Coccids and Psyllids). In a case like this it seems probable that the *Tetrastichus* fails to discriminate between the Coccid scale and the Psyllid gall, while the general similarity between the parasites of the two host groups is doubtless to be explained on phylogenetic and biological grounds.

2. *Status*.—The Encyrtids appear to be mainly primary parasites, but the relationship of the *Tetrastichus* spp. to their hosts is less certain. They are more likely to be secondary. André was definitely of opinion that *Agonioncurus* also played this rôle.

3. *Host stage attacked, etc.*—The majority of the records, when precise on this point, agree that the pupa of the host most commonly yields parasites. André, however, found larvae attacked as well. Normally, one Encyrtid hatches from a pupa. The specimens of the *Chiloneurus* described below were found singly, free from their pupal envelopes, each resting in a depression of the host pupa, their only covering being the crust of the gall. When this had been removed, the parasite floated off easily in potash. The *Chiloneurus* larva may therefore be an external feeder, at least, in its last stage (*cf.* André's remarks on *Tetrastichus obscuratus*).

In the notices of species already described it has been thought sufficient to quote only the essential facts of the parasitism in each case and the location of the type where known, but as Bulletin No. 5 of the U.S. Dept. of Agriculture, Div. of Entomology, 1885, is now scarce, the descriptions of Psyllid parasites which it contains have been repeated *in extenso*, as well as the notes on life-histories.

## Family Torymidae, Walker.

The following record of a "*Callimome*" attacking a Psyllid seems to me to be open to doubt, since the Torymids, when not phytophagous, appear to parasitise mainly Dipterous or Hymenopterous hosts.

### Genus **Callimome,** Spinola.

**Callimome pachypsyllae,** Vier.

*C. pachypsyllae*, Viereck, Guide to the Insects of Connecticut, iii, Hymenoptera (Bull. No. 22, State Zoological and Natural History Survey of Connecticut), Hartford, 1916, p. 516.

The reference is as follows :—

" *C. pachypsyllae* (Ashmead). *Monodontomerus pachypsyllae* Ashmead . . . . . reared from the Psyllid *Pachypsylla venusta* Osten-Sacken."

As I cannot trace any record of *Monodontomerus pachypsyllae*, Ashm., and the name appears to have existed up to 1916 in MS. only, its authorship should be credited to Viereck, not to Ashmead.

The description of the scutellum and hind femur indicate a *Monodontomerus* rather than *Callimome*.

## Family Encyrtidae, Walker.

### Genus **Sceptrophorus,** Först.

*Sceptrophorus*, Förster, Hymen, Stud. ii, p. 34, 1856.

Genotype, *S. sceptriger*, Först.

**Sceptrophorus solus,** How.

*Encyrtus solus*, Howard, Bull. No. 5, U.S. Dept. Agric. Bur. Entom., p. 15, 1885.

Referred to *Sceptrophorus*, Förster, by Ashmead (Proc. U.S. Nat. Mus., xxii, No. 1202, p. 381, 1900).

The original description is as follows :—

" 23. (7) *Encyrtus solus*, n. sp.

" This species also belongs to the group of *E. strobili* (L.), and does not differ structurally from *E. trioziphagus* to a material extent. In size and coloration it does differ quite markedly.

" *Female.*—Length, 2 mm. ; wing expanse, 4·2 mm. ; greatest width of fore wing, 0·7 mm. Mesonotum somewhat more deeply shagreened than with *trioziphagus*. Color : The basal portion of each antennal joint brown, distal portion honey-yellow ; face black, with a faint bluish tinge ; mesonotum black, faintly greenish ; abdomen shiny black. All legs entirely yellow, except hind coxae, which are black, with a greenish luster.

" Described from 1 ♀ specimen bred, March 14, 1879, from the gall of *Trioza magnoliae* (Ashmead), on *Persea carolinense* (Red Bay), collected at Gainesville, Fla. Its habits appear to be the same as those of the preceding species. [C.V.R. Coll.] "

*Type* ♀ in the United States National Museum.

### Genus **Psylledontus,** Crawf.

*Psylledontus*, Crawford, Proc. U.S. Nat. Mus., xxxviii, No. 1730, p. 88, 3.v.1910.

Genotype, *P. insidiosus*, Crawf.

**Psylledontus insidiosus,** Crawf.

*P. insidiosus*, Crawford, *loc. cit.*, p. 89.

U.S.A. : Geneva, New York ; bred from nymphs of the pear Psyllid, *Psylla pyricola*, Först. (*P. J. Parrott*).

*Type* in the United States National Museum.

**Psylledontus secundus,** Gir.

*P. secundus*, Girault, Ann. Ent. Soc. Amer., viii, No. 3, p. 281, Sept. 1915.

Ceylon : Peradeniya ; from gall-making Psyllids (nymphs) (*A. Rutherford*).

*Type* in the United States National Museum.

### Genus **Psyllaephagus,** Ashm.

*Psyllaephagus*, Ashmead, Proc. U.S. Nat. Mus., xxii, No. 1202, p. 382, 1900.

Genotype, *P.* (*Encyrtus*) *pachypsyllae*, How.

**Psyllaephagus pachypsyllae,** How.

*Encyrtus pachypsyllae*, Howard, Bull. No. 5, U.S. Dept. Agric. Bur. Entom., p. 15, 1885.

The original description is as follows :—

" 24. (8) *Encyrtus pachypsyllae*, n. sp.

" This species is closely related to *E. trioziphagus*. The minute spines at the distal end of the posterior tibia, opposite the tibial spur, are longer and more curved than with *trioziphagus*. The coloration differs in that with *pachypsyllae* the tibiae and tarsi are all light honey-yellow, and the flagellum of the ♂ antenna is light brown. The ♂ antenna also differs from that of *trioziphagus* in that joints 1, 2, and 3 of the funicle are fang-shaped instead of 2, 3, and 4. The dimensions on the average are the same in both species, although *pachypsyllae* is quite variable in the ♀.

" Described from many ♂ and ♀ specimens bred, between May 5 and 10, 1884, from galls of *Pachypsylla celtidis-gemma*, Riley, collected in Southern Maryland. [Dept. Agr. and C.V.R. Coll.]."

*Type* in the United States National Museum.

**Psyllaephagus trioziphagus,** How.

*Encyrtus trioziphagus*, Howard, Bull. No. 5, U.S. Dept. Agric. Bur. Entom., p. 14, 1885.

The original description is as follows :—

" 22. (6). *Encyrtus trioziphagus*, n. sp.

" *Female*.—Length, 1·3 mm. ; wing expanse, 2·9 mm. ; greatest width of fore wing, 0·51 mm. Antennal scape stout, short, not reaching to top of the eyes, with no foliation below ; pedicel short, conical, as thick as long and not exceeding in length the first funicle joint ; joints of funicle hard to distinguish, somewhat flattened and subequal in length, sixth as broad as long ; club subfusiform, as long as three preceding funicle joints together. Antennal grooves deep ; two slight malar impressions ; clypeus and vertex covered with fine punctures, lower face smooth, eyes wide apart ; ocelli form a very obtuse-angled triangle. Mesonotum delicately shagreened, with slight, sparse punctures, each giving rise to a short, delicate hair ; no marked difference between scutum and scutellum in punctuation ; axillae just meet at tips. Wings perfectly clear ; marginal vein wanting ; stigmal one-third longer than postmarginal. Abdomen nearly circular, sunken in center. Color : Flagellum of antennae brown ; scape and pedicel black, with a greenish luster ; lower part of face with a brilliant purplish-blue luster ; clypeus and vertex dark coppery-brown ; pronotum, coppery ; mesonotum bright shining green, the scutum somewhat more brilliant than the scutellum ; metanotum and abdomen shining black, with a dark green luster ; all coxae and femora dark green, honey-yellow at tips ; front tibiae honey-yellow, greenish at base ; middle tibiae entirely honey-yellow, sometimes with a slight green spot near base ; hind tibiae green, honey-yellow at either end ; front and hind tarsi brownish ; middle tarsi yellow.

" *Male*.—Length, 1 mm. ; wing expanse, 2·5 mm. ; greatest width of fore wing, 0·5 mm. Differs from ♀ chiefly in the antennae. The flagellum is much flattened ; scape still shorter than in ♀ ; pedicel very short and insignificant ; joint 1 of the funicle twice as long as wide, and three times as long as pedicel ; joints 2, 3, and 4 are fang-shaped dorsally ; joint 3 more acute than 2 and 4 ; joints 5 and 6 resemble joint 1 in size and proportions : club short and suboval. Abdomen short and subcordate in form.

" Described from 4 ♀'s and 2 ♂'s bred, November 7, 1881, from the galls of the Psyllid *Trioza diospyri* (Ashmead), on the Persimmon (*Diospyros virginiana*) on the Department grounds at Washington.

"This species is markedly different from *Encyrtus triozae*, André, bred by M. Ed. André from *Trioza centranthi*, Vallot, and described in Ann. Soc. Ent. France, 1878, p. 84 ; but belongs to the same group of the genus *Encyrtus* as *E. strobili* (L.), to which it is quite closely related. *E. strobili*, however, preys upon certain gall-making Cecidomyids, as *Cec. rosaria* and *C. salicina*.

"A single *Encyrtus* issued from a single *Trioza* in every case, making its way through the dorsum of the abdomen of its host. [Dept. Agr. and C.V.R. Coll.]."

*Type* in the United States National Museum.

**Psyllaephagus metallicus,** Gir.

*Aratus metallicus*, Girault. (I cannot trace this species under *Aratus*.)

*Psyllaephagus metallicus*, Girault, Mem. Queens Mus., iv, p. 119, 4.vi.1915.

AUSTRALIA : Queensland, Brisbane ; bred out of *Eucalyptus*, 5.viii.1911, gall no. 15 (*H. Hacker*).

*Type* ♀ in the Brisbane Museum.

**Psyllaephagus femoralis,** Bor.

*P. femoralis*, Borelli, Bull. Soc. Entom. Ital., li, p. 32, 1919 (published 25.vii.1920).

ITALY : near Bologna ; from galls of *Trioza alacris*, Flor., on *Laurus nobilis*, L.

*P. femoralis* oviposits in both larvae and pupae of its host and is an internal feeder.

**Psyllaephagus cellulatus,** sp. nov.

♂, ♀. A metallic green species with pale anterior legs and a conspicuous incomplete sub-basal band on the hind tibiae.

♀. Vertex of head and thoracic notum dark metallic green, with aeneous reflections. Frons of a rich dull metallic violet, with the dark green colour reappearing between the toruli and continuing towards the mouth-edge, which is aeneous green. Sternopleurae more aeneous than the notal surface. Tegulae pale, infuscated on apical third. Abdomen purplish black and at most submetallic. Wings hyaline. Mentum and stipes blackish-brown. All the palpi, galea, lacinia and ligula conspicuously pale. Antenna, bulla, scape (except narrowly at apex) and pedicel dorsally, blackish brown ; apex of scape and sometimes pedicel ventrally towards its apex, a little paler ; the remainder of the antenna pale, the funicular segments more or less faintly infuscated but always sharply contrasted with the scape. Legs with all the coxae like the thorax and submetallic ; fore and mid legs entirely pale, the fore femora at most faintly infuscated on proximal half ; hind trochanters and extreme base of femora pale ; thereafter the femora black or blackish-brown, with the apical sixth pale ; base of tibia pale to about the length of the corresponding apical area of the femora, followed by a broad dark spot (most distinct dorsally), which forms a nearly complete band extending to over one-third from the base ; remainder of tibia and tarsus pale. (In none of the tarsi is the last joint very appreciably darker than the others, but the specimens have all been in spirit.)

♂. The green of head and thorax is more emerald. Frons concolorous with vertex. Bulla and scape very pale, paler than funicle, only the pedicel is definitely blackish-brown on the proximal two-thirds, its apex (transversely) being pale. In the hind femur the apical third is pale, and the sub-basal band is less extensive, being reduced to a spot on the dorsal edge.

♀. *Head* nearly one-fourth wider than deep. Toruli (2 : 1) mainly below the base line of the eyes, relatively as far apart as in the ♂, but only about two-thirds their length from the mouth-edge. Antenna (fig. 1, *c*), length 0·6 mm. ; 12 (11)-jointed ; scape (9 : 2) thrice as long as and of the same breadth as the pedicel

(8 : 3). The funicular joints increase in length gradually, 11, 13, 15, 16, 16, 17, with breadths respectively 11, 12, 13, 14, 16, 18. The club is three-fourths the scape in length, or equal to the sum of the first four or the last three and a half funicular joints. Sensoria, 0, 1, 2–3, 3, 3, 4–5, and in club segments 5–6, 7, 5.

*Thorax*. Pronotum with a posterior row of about 30 bristles; axillae not quite touching. Scutellum with about 50 (25 : 25) bristles.

*Wings*. Fore wings, length, 0·93 mm.; breadth, 0·41 mm.; submarginal, radius (fig. 1, *a*) postmarginal, 10 : 2 : 1. The punctiform marginal is much broader than long (fig. 1, *a*), submarginal vein with about 11 bristles. Submarginal cell,

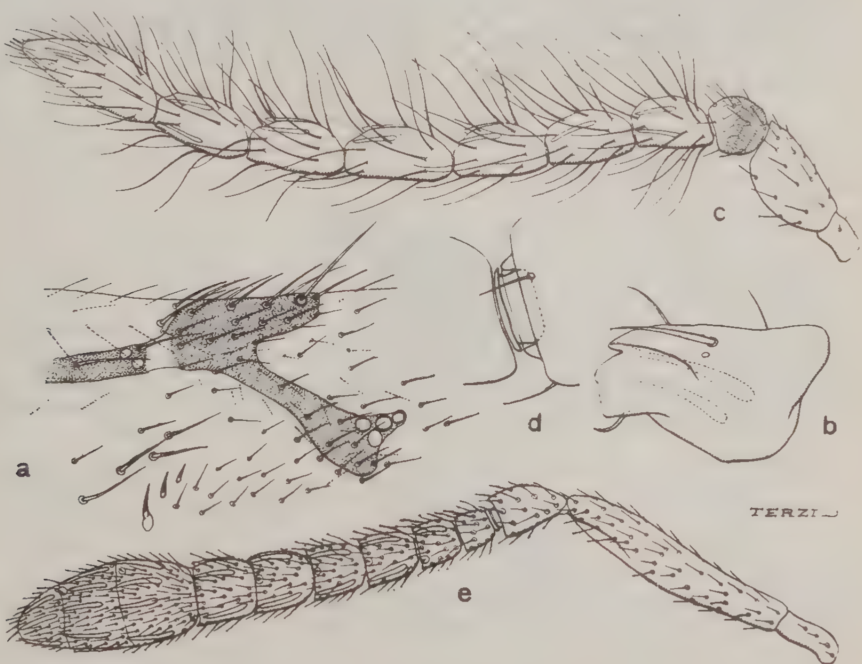



Fig. 1. *Psyllaephagus cellulatus*, sp. n.: *a*, radius of ♀; *b*, mandible of ♀; *c*, antenna of ♂; *d*, ring-joint of same; *e*, antenna of ♀.

upper surface near edge with a row of about 20 minute bristles. Ventral surface entirely covered with minute fine bristles (about three rows), about six of which towards the apex are much longer. Hind wings, length, 0·6 mm.

*Legs*. Fore legs with coxa (4 : 3) coarsely reticulate; femur (3 : 1) one-twelfth longer than the tibia (4 : 1), which is broad; upper tooth-like apical angle of tibia well developed, apical comb of six spines; comb of first tarsal joint with about 14 spines; tarsus 15, 10, 10, 9, 16. Mid leg tibia at one-third from base nearly ten, at apex about six times as long as broad; apical teeth 7, on tarsal joints 1–4: 8, 5, 3–4, 1–2; tarsus 23, 14, 11, 10, 15. Hind leg with coxa 10 : 11; femur (27 : 8) shorter (4 : 5) than tibia (6 : 1); apical comb of tibia with 20 spines; 10–11 spines along postero-ventral edge of first tarsal joint; tarsus, 21, 13, 11, 18.

*Abdomen* with pattern on tergites rather coarse and a little raised. Tergite 1 the longest, occupying over one-fifth of the length. Tergites 2–4 show antero-medianly

an uncoloured membranous area, concealed for the most part beneath the posterior edge of the preceding tergite. At the extreme side of their dorsal portion the tergites show one or more strongly marked cell-like chitinisings (fig. 2, *a*). Spiracle small, circular. Stylet with three major and two minor bristles, the longest four-fifths the distance between the processes themselves. Free portion of ovipositor sheath one-fourth of the base.

*Length*, 1·4 mm.; alar expanse, 2·4 mm. (In the largest ♀ the length is 1·6, expanse, 2·7; fore wing, 1 mm.)

♂. *Head* one-fifth wider than long (deep); eyes occupying two-thirds of the depth, separated at the level of the anterior ocellus by half and at the base line by seven-ninths of the greatest width. Toruli (3 : 2) lying mainly above the base line of the eyes; separated ventrally by nearly twice or from the mouth-edge by nearly one


Fig. 2. Right half of second tergite of (*a*) *Psyllaephagus cellulatus*, sp. n.; (*b*) *Encyrtus pulvinatus*, sp. n.

and a half times their length. Whole surface with rather fine strongly raised pattern and numerous short bristles, of which over 30 stand on the combined inter- and infra-torular areas, four of them above the straight clypeal edge being a little longer. Antenna (fig. 1, *c*), length, 0·7 mm.; 9 (10)-jointed; scape (2 : 1) more than twice (7 : 3) as long as and a little broader (7 : 6) than the pedicel (1 : 1). The latter nearly circular, with an extremely coarse reticulation. Ring joint (fig. 1, *d*) very minute, nearly concealed in the pedicel. The first two joints of the funicle together about one-fourth longer than the scape, or one-eighth longer than the club. The proportions of the funicle joints and club are: length, 26, 27, 28, 32, 32, 32, 50; breadth, 17, 18, 18, 17, 16, 17, 19. The club is solid; tubular hairs numerous, as in fig. 1, *c*. Labrum narrow, faintly concave, nearly straight, with five bristles; mandible as in fig. 1, *b*; maxillary palpi, 9, 9, 9, 20; labial palpi, 11, 6, 10.

*Thorax.* Pronotum with 20–22 bristles in the posterior row. Mesonotum with the scutum pattern fine, strongly raised. Axillae not touching. On the scutellum the cells are more drawn out and equally raised. Whole mesonotum with numerous short bristles, of which upwards of 30 (15–17 : 15 17) stand on the scutellum. Metanotum and propodeon rugulose; pleurae of propodeon beyond the spiracle with numerous bristles. Spiracle broadly oval—the long axis transverse.

*Wings* similar to those of ♀. Submarginal cell with only 2 3 longer bristles apically, and only about two rows of minute bristles on underside on apical half.

*Legs* similar to those of ♀.

*Abdomen.* The thickened cells at the side of the tergites are much less numerous, *e.g.*, in the second tergite only two such cells occur on each side (*cf.* fig. 2, *a*).

*Length*, 1·3–1·4 mm.

*Type* ♀ in the British Museum, one of a series of 3 ♂, 7 ♀; alar expanse, a little over 2 mm.

From *Rhinocola populi*, Laing, attacking *Populus euphraticus*.

MESOPOTAMIA: Baghdad, Beled Ruz, 16.vi.1920 (*Y. Ramachandra Rao*).

## Genus **Encyrtus,** Dalm.

*Encyrtus*, Dalman, Svensk. Vet.-Akad. Handl., xli, p. 147, 1820.

That either of the following species is in the strict sense an *Encyrtus* is debatable. With André's species I have no direct acquaintance, and so have left it as the author placed it. *E. pulvinatus*, sp. n., differs from the other *Encyrtus* spp. known to me mainly in its type of colour pattern, somewhat shorter marginal vein and its mandibles. It may represent a new genus, but little inconvenience should result from its present placing. In any case its final position cannot be fixed till the male is known.

### **Encyrtus triozae,** And.

*E. triozae*, Ed. André, Ann. Soc. Ent. France, (5) viii., p. 84, 26.v.1878.

FRANCE: Côte-d'or.

From galls of *Trioza centranthi*, Vallot, on *Centranthus angustifolius*, D. C.

André states that *E. triozae* is an internal feeder on both larvae and pupae, but to the description itself he appends merely the words "habitat in pupis *Triozae centranthi*, Vallot."

### **Encyrtus pulvinatus,** sp. nov.

♀. A dark metallic (?) green species, with conspicuously pale legs. The second tergite of the abdomen is characteristic. Body dark green, the scutellum matt. Antennae very pale brown, a little darker on scape, pedicel (dorsally) and club. Wings faintly but completely brown-tinted. Fore legs (including coxae) entirely pale, except for the fifth tarsal joint, which is infuscated as in the mid and hind legs; mid legs pale except for faintly brown coxa and fifth joint of tarsus; in the hind legs the coxa (except near the trochanter) and the distal two-thirds of the femur are brown, the rest pale.

*Note.*—The general body colour may have altered a little in alcohol but it appeared to be mainly dark green. The clear spot between the marginal and submarginal veins is indistinct.

♀. *Head* broader than long (deep) (9 : 8); eyes half as long again as the genal space, sparsely pilose, separated at their nearest by three-fifths the width of the head. Toruli elongate (2 : 1), about their own length from the mouth-edge, distinctly below the base line of the eyes, separated ventrally by one and a half times and

above by a little more than their length, scape hollow, as long as the toruli; whole face above the grooves strongly raised reticulate. Two bristles on clypeus and about seven on each side of the inter-torular area; 4–5 bristles on each side in a group below the anterior ocellus, besides the usual orbital bristles (12–15). Labrum simple, transverse, very slightly concave, with six stout spinose bristles. Mandibles similar, no distinct teeth (fig. 3, *b*). Maxillary palpi, 8, 4, 5, 11, the third joint with four bristles, the fourth with nine, of which three are apical; galea with 5–6 marginal bristles and 18–20 on the upper flap; labial palpi, 7, 4, 6, the second joint with two bristles, the third with five. Antenna (fig. 3, *a*), 0·7 mm. long; scape (9 : 2) not greatly expanded (three times as long as the pedicel (9 : 5) or one-third longer than the club, or just longer than the pedicel, ring joint and first three funicular joints taken together) with besides the usual superficial bristles one long externally sub-apical and ventral and a ventral row, about six, on the inner aspect. Funicular joints and segments of club, measured ventrally, in ratio 16, 15, 15, 22, 22, 22—22, 20, 18, with breadths 12, 12, 14, 15, 18, 20–25, 22. Joints 4–6 of the funicle bear 2–3 sensoria each, and on the club segments there are 4, 4, 2.

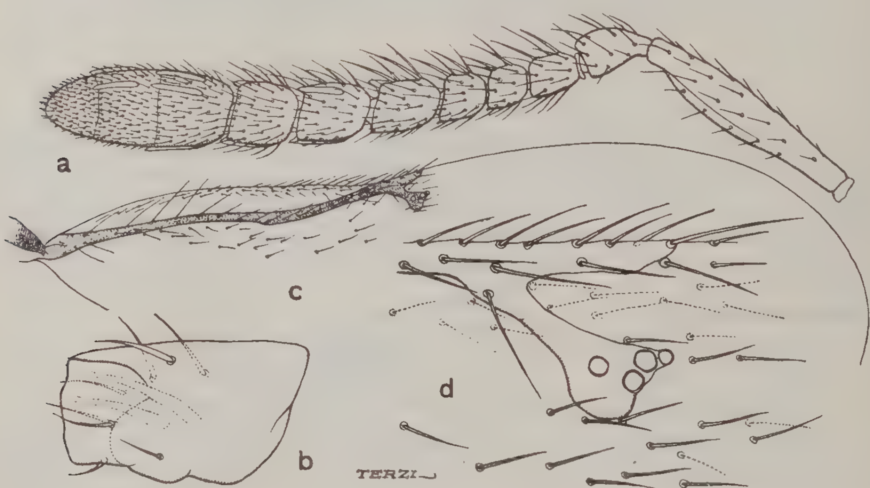



Fig. 3.—*Encyrtus pulvinatus*, sp. n., ♀: *a*, antenna; *b*, mandible; *c*, neuration; *d*, radius.

*Thorax.* Mesonotum scaly reticulate, pattern fine, raised, with 70–80 bristles. Axillae not quite meeting. Four bristles. Scutellum matt, pattern coarser and strongly raised in front of the sensory pustules, but a little smoother behind; the latter area has four bristles (2, 2), while there are about 25 bristles anteriorly on the rougher area. Mesopleurae anteriorly striate-reticulate, posteriorly reticulate, as is also the sternal area. Propodeon medianly smooth, laterally striate; spiracle at antero-lateral angle; metasternum medianly finely pitted and rough (strongly and deeply raised reticulate).

*Wings.* Fore wings (fig. 3, *c*, *d*), length, 1·25 mm., a little more than twice (40 : 19) as long as broad. Submarginal, marginal, radius, postmarginal 19 : 2 : 3 : 2. About 14 bristles on the submarginal, eight along the edge of marginal and postmarginal and as many more on the veins themselves, and on the radius towards the base; 5–6 rows of discal cilia between the "hairless line" and the base of the wing. Hind wings, 0·8 mm. long.

*Legs.* Fore coxae (5 : 3) with numerous bristles on outer aspect, about two-thirds as long as the femur (22 : 5) which is a little longer (11 : 10) than the tibia (5 : 1); tibial comb with 5–6 spines, comb of first tarsal joint 10–11 spines. Mid legs with femur (about 15 : 2) as long as the tibia, which is very narrow (about 12 : 1) medianly but more expanded (about 6 : 1) at the extreme apex, where there are four heavy spines; on first tarsal joint four spines in a lateral row, followed by two transverse rows (subapical and apical) of three each, joints 2–4 with transverse apical row of 3–4 spines and one extra on plantar aspect; the tibial spur is just longer than the first tarsal joint measured ventrally. Hind legs with coxa as broad as long, with about 25 rather long bristles externally; femur (about 17 : 4) shorter (8 : 9) than tibia (6 : 1), comb with 12–14 spines, longer spur not half the first tarsal joint; the latter with 6–7 spines along the ventral edge; in the tarsi of all the legs the third and fourth joints are subequal and the first half as long again as the second.

*Abdomen* one and a half times as long as broad from above. The tergites are medianly nearly smooth, with slightly raised pattern on the overlaps and posteriorly from about the level of the stylets. Tergites 1–3 are band-like and comparatively simple, the second bearing anteriorly at each side a small patch (occupying rather less than one-fourth of the dorsal breadth of the tergite) of highly raised minute cells, which doubtless give a foothold to the ♂ (fig. 2, *b*); tergite 4 is narrow, band-like medianly, subconcave along the posterior edge, and deeply and roundly excised between the tergal and pleural regions; tergites 5 and 6 are postero-medianly convex with nearly separated triangular overlaps; spiracle small, broadly oval; tergite 7 is truncate trapezoidal, the sides converging posteriorly. Each tergite 1–6 bears 4–5 bristles at each side with a bare space between, but on the sixth the row is continuous; on the overlaps of 1–4 there is at most one bristle, of tergite 5 about half a dozen, of tergite 6 about 10; on tergite 7 there are upwards of 30 bristles. Medianly the entire venter is densely set with bristles. The free portion of the sheath is less than one-third of the base.

*Length*, about 1·4 mm.; alar expanse, about 2·8 mm

*Type* ♀ in the British Museum.

Bred from *Trioza citri*, Laing, attacking *Citrus*.

KENYA COLONY: Kabete, 1920 (*F. W. Dry*).

## Genus **Chiloneurus**, Westw.

*Chiloneurus*, Westwood, Phil. Mag., iii, p. 343, 1833.

### **Chiloneurus praenitens**, sp. nov.

♀. A small species, with pale head and thorax and dark abdomen. The scape is greatly dilated.

Head, propodeon and abdomen shining, thorax dull. Head and thorax mainly clear light brown (honey-coloured), eyes chocolate coloured; antennae as in fig. 4, *a*. Pronotum with a minute dark spot at each lateral angle and a large one antero-medianly above the neck, occupying two-fifths of the breadth and three-fifths of the length. The posterior dark band on the mesoscutum is completely transverse and occupies about one-fourth of the length. Propodeon darker than the rest of the thorax. Fore and mid coxae very pale, those of the mid legs faintly embrowned. Legs otherwise pale, with the following exceptions: fore femur (narrowly) above, mid femur shortly preapically (very faintly) brown, a dark spot superiorly near base of the tibia. Heavy tarsal spines all pale. Hind legs with femur dorsally, indistinctly and faintly, darker; tibia with two faint spots, one at one-third, the other at two-thirds, apex of tibia very pale. Fore wing practically hyaline as far as the uprise of the submarginal to the marginal, *i.e.*, the radical spot is nearly absent; the

cloud is concave distally, about one-ninth of the wing apically being clear. Hind wing hyaline. Abdomen, dark brown, with bluish or violet metallic reflection. Ovipositor pale.

*Head* (fig 4, *b*) wider than deep—about 6 : 5 when viewed from in front at right angles to the transverse ridge between the upper surface (vertex and frons) and the lower frons (scapal hollows and inter-torular area). Upper orbits practically parallel, the frons at its narrowest (halfway between the anterior ocellus and the ridge) rather less than one-fourth the width of the head. Upper frons smooth, its pattern fine and hardly raised. Ocelli in an equilateral triangle ; the posterior pair widely separated, each being less than a diameter from the orbit and from $1\frac{1}{2}$–2 diameters from the occipital edge. Inter-torular area smooth and declivous about the mid line, but without a definite carina or edge. Antenna (fig. 4, *a*), 0·65 mm. in length ; scape (16 : 7) greatly expanded, widest above the middle, longer than the club, two and a half times as long as the pedicel, which is equal to the first three funicular joints together ; the first funicular is quadrate, the rest transverse ; club only a little shorter (9 : 10) than the funicle, and though much swollen hardly as broad as the scape. Mouth-parts : labrum normal, transverse, short, distinctly concave, with six bristles (3, 3) ; mandibles (14 : 9) tridentate ; maxillary palpus, 13, 9, 9, 8.

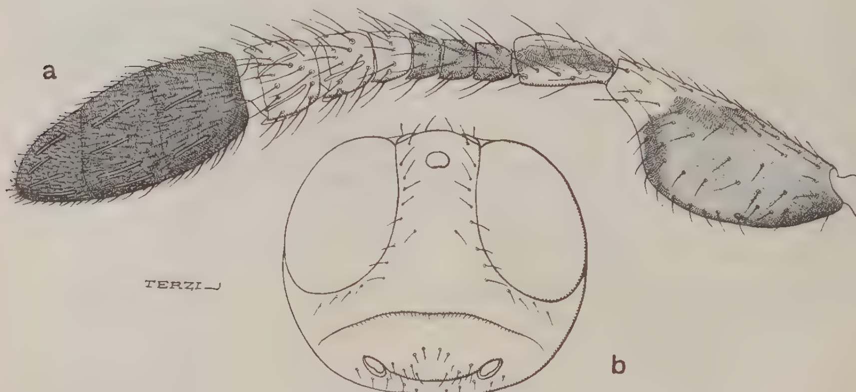



Fig. 4. *Chiloneurus praenitens*, sp. n. : *a*, antenna ; *b*, head.

*Thorax*. In the mesonotum the anterior two-thirds (*i.e.*, up to the dark band) bears about 30 dark bristles, and the surface is entirely covered by a moderately fine raised rugose striation—the striae being straight and subparallel. The dark band is covered by the usual belt of sword-like hyaline bristles, which lie parallel to one another and overlapping, and produce by interference the silvery play visible in this region. There are about three rows of these peculiar bristles. Scutellum with deeply raised reticulation. Axillae with five bristles.

*Wings*. Fore wings (5 : 2), length, 0·9 mm., submarginal vein (about five times the marginal) bearing five dark and two hyaline bristles before the uprise, on the marginal stand 18–20 dark stout bristles and about half a dozen project at the edge from the numerous bristles below. Radius with one bristle near base and one near apex. Behind the submarginal the wing is nearly bare, there being only 3–6 fine hyaline bristles opposite the two similar bristles on the nervure and about 15 short stout dark bristles in 2–3 irregular rows on the basal side of the "hairless line." On the submarginal cell below are 10–12 minute hyaline bristles on the basal two-thirds and 2–3 darker and longer ones at the apex. Hind wings (4 : 1), length, 0·75 mm.

*Legs.*—Tarsal joints 1 and 2 in ratio 21 : 15. Mid legs, tibia with five spines at apex; tarsal joints 1 and 2 in ratio 35 : 20; the spines on joints 1–4 are 11–12 : 4 : 3 : 3.

*Length*, 1·3–1·4 mm.; alar expanse, 2·1–2·3 mm.

*Type* ♀ in the British Museum; one of a series of four taken from galls of a Psyllid (? *Trioza* sp.).

JAMAICA: Hill Gardens, 9.ii.1921 (*C. C. Gowdey*).

This species belongs to the *formosus*, Boh. (1852) *cyanonotus*, Waterst. (1917), *dactylopii*, How. (1885), section of the genus. It should be easily recognised by its small size, colour, and antennal characters.

The following genus is, as a rule, placed in a subfamily (SIGNIPHORINAE) of the ENCYRTIDAE.

Genus **Signiphora**, Ashm.

*Signiphora*, Ashmead, Orange Insects, p. 30, 1880.

Genotype, *Signiphora flavopalliata*, Ashm. (*l.c.*).

**Signiphora noacki,** Ashm.

*S. noacki*, Ashmead, Proc. U.S. Nat. Mus., xxii, p. 410, 1900

BRAZIL: San Paulo.

From *Psylla* sp. on a wild shrub, bred October 1897 (*F. Noack*).

*Type* ♀ in the United States National Museum.

**Signiphora unifasciata,** Ashm.

*S. unifasciata*, Ashmead, Proc. U.S. Nat. Mus., xxii, p. 411, 1900.

U.S.A.: Florida, Georgiana (*Dr. Wittfield*).

From *Ceröpsylla sideroxyli*, Riley.

*Type* ♀ in the United States National Museum.

Of the following species I know nothing at first hand: *Agonioneurus*, Westwood (1833), is a synonym of *Aphelinus*, Dalm. (1820), but (from description) I am doubtful whether André's insect really belongs here.

**Agonioneurus pictus,** And.

*Agonioneurus pictus*, Ed. André, Ann. Soc. Ent. France, (5) viii, p. 85, 26.v.1878.

FRANCE: Côte-d'or.

From galls of *Trioza centranthi*, Vallot, on *Centranthus angustifolius*, D.C.

Bred from the same larvae that gave rise to *Encyrtus triozae*, And., and considered by André to be probably a hyperparasite.

Family PTEROMALIDAE, Walker.

Genus **Pachyneuron,** Walker.

The species described below runs down to *Pachyneuron*, Walker (Ent. Mag., i, p. 371, 1833) of which genus, however, it is not a typical exponent, differing as it does from *P. formosum*, Walk. (*loc. cot.*, p. 380) in the shortened first funicular joint.

**Pachyneuron crassiculme,** sp. nov.

♀. Head and thorax black, with at most faint violet submetallic reflections. Abdomen blackish-brown, not quite so dark as the rest of the body, with submetallic reflections only on the two basal tergites. Antennae blackish-brown, a little paler on

club and base of scape. Trophi blackish-brown ; palpi white, except the basal joint of the maxillary, which is a little infuscated. Wings, hyaline. Coxae black, of the hind legs submetallic on outer side ; all trochanters and fore tibiae pale, as are also the tarsi, of which the fifth joint is definitely infuscated only in the hind legs. Femora more or less infuscated on basal two-thirds (in the front pair mainly ventrally) and pale apically. In the mid and hind tibiae the basal one-seventh or one-eighth and the distal half are pale, the remainder being more or less infuscated, particularly dorsally.

*Head* (fig. 5, *a*) with surface evenly raised, reticulate and shining ; towards the mouth-edge the pattern is drawn out ; edge of clypeus with three lobes, the middle one somewhat broad (fig. 5, *a'*) but more pointed when seen from in front.

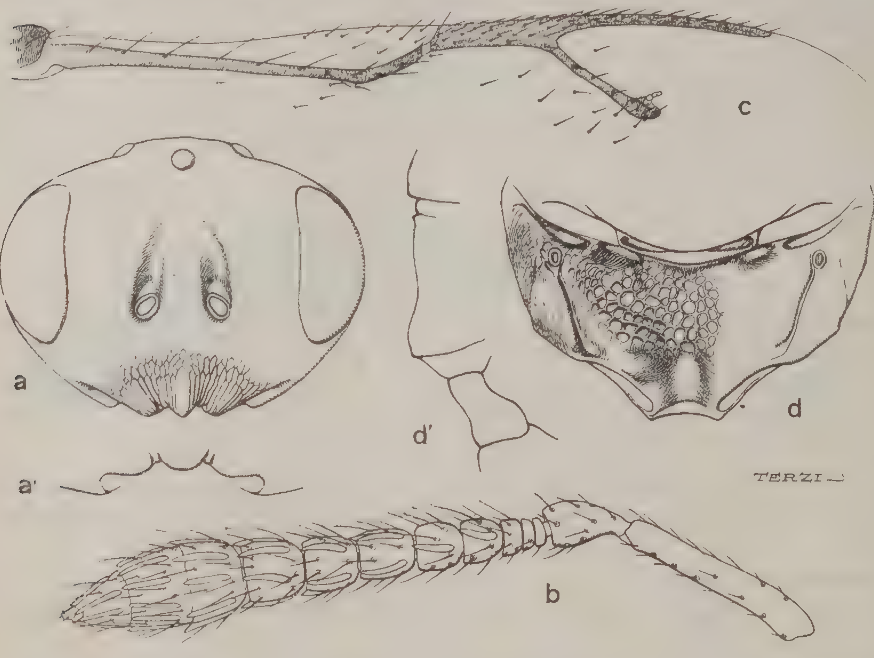



Fig. 5. *Pachyneuron crassiculme*, sp. n., ♀: *a*, head ; *a'*, mouth-opening ; *b*, antenna ; *c*, neuration *d*, propodeon ; *d'*, propodeon and petiole in profile.

Antenna (fig. 5, *b*), length, 0·52 mm. ; scape (5 : 1) widest near base, two and a half times as long as the pedicel (barely 2 : 1) and as long as the funicle up to the middle of its penultimate joint (*i.e.*, equal to ring joints and four and a half subsequent joints) and one-fifth longer than the club ; the two ring joints and the first and second funicular joints together as long as the pedicel ; the first funicular very short (1 : 2) and ring-like, and only half as long as the second, which is quadrate, as is also the third ; the fourth joint cylindrical and about one-half longer than the third, being just longer than the fifth and as long as the sixth, which is the broadest in the funicle ; the lengths of joints 1–6 approximately 5½, 11, 11, 15, 14, 15, and the breadths, 10, 11, 12, 14, 14, 16 ; the club longer than the three preceding joints together and much wider (11 : 8) than the last funicular joint, segmented in ratio 14 : 16 : 18, with breadths of 22 and 16 ; the funicular joints have the following sensoria 0, 2, 2, 4, 4, 6, and the club, 7, 9, 7. Mandibles both quadridentate, the teeth deeply separated. Maxillary palpi, 7 : 10 : 10 : 20 ; labial palpi, 12 : 3 : 12.

*Thorax*. Pronotum completely margined ; parapsidal furrows distinct anteriorly and traceable backwards to nearly one-half ; general surface shining, but evenly reticulate, most raised on mid lobe. Propodeon (fig. 5, *d*) with spiracle small, oval ; lateral fold distinct, nucha short and shining ; entire surface reticulate, but raised and a little dull, broadly, in the middle ; the sides, though reticulate, are smooth and shining. Petiole short and rather deep, about half the length of the propodeon (fig. 5, *d'*).

*Wings*. Fore wings (fig. 5, *c*), length, 0·83 mm., two and a quarter times as long as broad ; submarginal, marginal radius and postmarginal approximately 14 : 5 : 5 : 8 ; the radius more exactly is about one-tenth longer than the marginal, the latter being much thickened and varying from five (at the junction with the submarginal) to four and a half (at the origin of the radius) times as long as broad ; the radial knob is narrower than the marginal, and near its origin the vein itself attains to only one-third of the greatest width of the marginal. Chaetotaxy : submarginal with 9–10 bristles, 6–7 (stouter) at the edge of the marginal, and about a dozen fringing the postmarginal ; on the broad surface of the marginal are about 25 bristles in roughly three rows ; 6–7 on the radius ; on the postmarginal (apart from the fringing bristles) there are about 30 more in two irregular rows. The fringe is short and the distal ciliation not very dense ; on the distal half of the subcostal cell are 9-10 short bristles near the edge ventrally. Hind wings, length, 0·66 mm.

*Legs*. Fore legs, coxa (7 : 4) with coarse raised reticulation on outer aspect, half as long as the trochanter and femur combined ; femur (30 : 7) just longer (18 : 17) than the tibia (6 : 1), which is as long as the tarsus excluding the ungues ; on the tibia the spur is at one-seventh from the apex, with three spines between it and the lower ventral angle, two more on outer lateral aspect apically and two on inner face subapically ; comb of first tarsal joint with 10 spines ; tarsus 24, 16, 13, 11, 20. Mid legs, tibia (11 : 1) about one-fourth longer than femur (11 : 2) ; tarsus 27, 21, 17, 13, 22. Hind legs, femur (21 : 5) shorter (7 : 8) than tibia (8 : 1) ; apical comb of tibia with 10 spines, spur two-thirds of first tarsal joint ; tarsus 30, 24, 18, 15, 24.

*Abdomen*. Smooth, shining, nearly as long as head and thorax together ; post-petiolar segment occupying rather less than one-third of the length, ovipositor hardly at all projecting. The petiole (fig. 5, *d'*) is very short.

*Length*, 0·75 mm. ; alar expanse, 1·8 mm.

*Type* ♀ in the British Museum.

From *Rhinocola populi*, Laing, attacking *Populus euphraticus*.

MESOPOTAMIA : Baghdad, Beled Ruz, 16.vi. 1920 (*Y. Ramachandra Rao*).

Family EULOPHIDAE, Westw.

Genus **Tetrastichus**, Hal.

*Tetrastichus*, Haliday, Trans. Ent. Soc. Lond., iii, p. 297, 1843.

Genotype, *T.* (*Cirrospilus*) *Attalus*, Wlk.

**Tetrastichus obscuratus**, And.

*T. obscuratus*, Ed. André, Ann. Soc. Ent. France, (5) viii, p. 83, 26.vi.1878.

FRANCE : Côte-d'or.

From galls of *Trioza centranthi*, Vallot, on *Centranthus angustifolius*, D.C.

Commenting on the finding of this *Tetrastichus*, André remarks : " Le parasitisme est donc incontestable, et de plus il se produit extérieurement au moins en partie, puisque la nymphe n'est pas contenue dans l'insecte devoré."

**Tetrastichus sicarius,** Silv.

*T. sicarius*, Silvestri, Boll. Lab. Zool. R. Sc. Agr. Portici, ix, p. 325, figs. lxxiv–lxxv, 20.ii.1915.

KENYA COLONY: Songhor.

"Reared from heavily parasitised Citrus *Psylla*," 2 ♂, 4 ♀, ix.1917 (*F. W. Dry.*).

This species has also been bred from several African Coccids (various localities) and from *Lecanium viride* in Mauritius.

**Tetrastichus dryi,** sp. nov.

A blackish species without strong metallic reflections, with a conspicuous pale basal spot on the abdomen (♂) and somewhat extensively pale legs. The ventral sensorium of the scape short—much less than the breadth of the scape. The funicle with whorls of long tubular bristles.

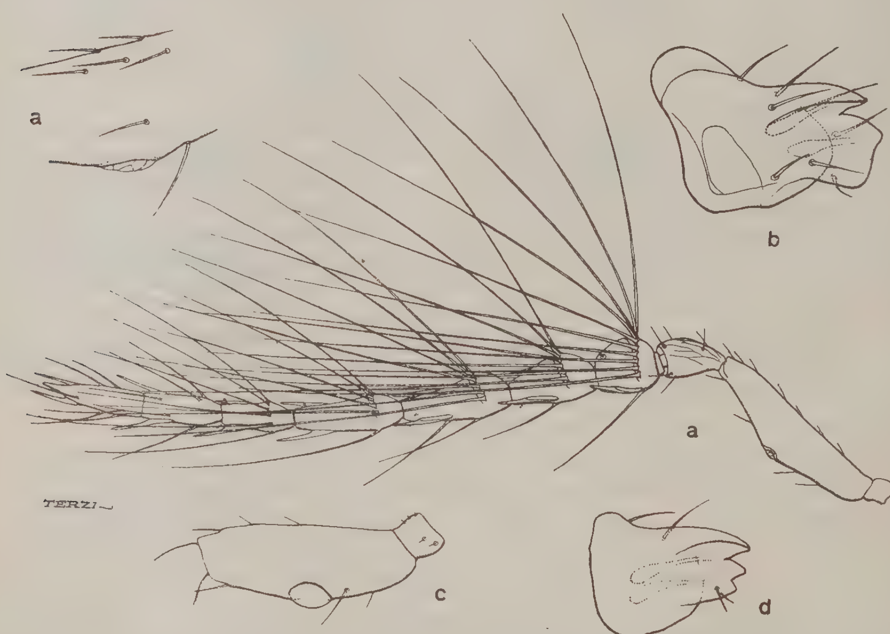



Fig. 6. *Tetrastichus dryi*, sp. n., ♂: *a*, *a*, antenna, and scapal sensorium enlarged; *b*, mandible. *Tetrastichus maculifer*, Silv., ♂: *c*, scape and sensorium; *d*, mandible.

♂. Body and coxae blackish, the pale abdominal spot extending over the apical third of tergite 1 and about two-fifths of the breadth, across tergite 2 and just touching on tergite 3 anteriorly. Antennae uniformly but not deeply infuscated, except for a paler median stripe on the scape. Trophi like antennae. Nervures distinctly pale brown. Fore and mid tibiae and all the tarsi pale—the fifth joint of the latter only faintly embrowned; fore femora a little embrowned basally (more particularly dorsally) and becoming gradually paler near the apex; mid femora pale brown, hardly lighter at apex; hind femora and tibiae uniformly brown, the latter of a lighter shade.

*Head* (8 : 5). Antenna (fig. 6, *a*, *a'*) 0·87 mm. ; scape (15 : 4) longer (5 : 2) than the pedicel (2 : 1) and *only three-fourths as long as the club, excluding the spur* ; *the second funicular joint five-sixths of the third*. The longest bristles on the first funicular extend well on to the first segment of the club, whereas in *T. radiatus* they do not pass the end of the funicle. The funicular and club segments are also both absolutely longer and narrower than in the Indian species. The longest ventral bristle of the first club segment is four-fifths of the club, including the spur.

*Thorax*. Pronotum with the posterior row only of eight (4, 4) bristles, *including* the spiracular bristles. Propodeon with the median keel narrow ; on the inner (admedian) side of the spiracle and at less than its transverse diameter from the spiracle, a short curved keel runs backwards to beyond middle ; a similar ridge starting from the posterior edge halfway between the mid keel and the hind coxae, runs forward to beyond middle and parallel for a short distance with the former. Whole surface of propodeon more irregular. Spiracle set well forward, not more than one-third its own length from the anterior edge of the sulcus, and actually touching the posterior one.

*Wings*. Fore wings, length, 1·1 mm. The marginal vein narrow ; 4–5 bristles on radius, longest marginal cilia one-seventh the width. Hind wings, 0·9 mm. ; no cilia as long as the width.

*Legs* : tarsal proportions :—(i) 15, 24, 23, 30 ; (ii), 20, 25, 24, 30 ; (iii), 20, 25, 24, 30.

*Abdomen* with four bristles between the stylets.

*Length*, about 1·3 mm. ; alar expanse, 2·6 mm.

*Type* ♂ in the British Museum.

Bred from *Trioza citri*, Laing, attacking *Citrus*.

KENYA COLONY : Kabete, 1920. (*F. W. Dry*).

*T. dryi* is unlike any other African *Tetrastichus* with which I am acquainted, except *T. maculifer*, Silv. I desire to thank Prof. Silvestri very heartily for an opportunity of examining the type of his species. The following comparative notes may be given :—

In *Tetrastichus maculifer*, Silv., the scape (about 8 : 3) is barely twice as long as the pedicel and about five-sixths of the club not including the spur (fig. 6, *c*). The sense organ is half as long as the greatest breadth, *i.e.*, relatively longer than in *T. dryi* and *T. radiatus*. There are on the funicular joints and first of the club the following tubular hairs : 6, 4, 4, 3, 1 ; no sense-organ on the first funicular and one on the other joints and club segments. The longest ventral tubular bristle on the first segment of the club is about one-fourth as long again as the club including the terminal spur, while the ventral bristle on the second segment is as long as the club without the spur. The mandible (fig. 6, *d*) is definitely tridentate. On the mid lobe of the mesonotum are two bristles before the suture on the proximal third. The spiracle of the propodeon is small, at rather more than its own length from the anterior edge, and about one-third as long as the mid keel. In the fore wings the longest cilia are two-sevenths of the breadth, in the hind wings nearly half as long again as the breadth. Besides the bristles enumerated each segment of the funicle bears one (not strictly in the whorl) laterally about or below the middle, and the last segment and the club segments have a long ventral bristle as well.

**Tetrastichus radiatus,** sp. nov.

Similar in colour and structure to *T. dryi*, sp. n., but differing in possessing almost entirely pale legs, the hind femora at most with a trace of infuscation dorsally. In the ♂ the sense-organ also is lower down on the ventral edge of the scape, and the antennal proportions generally are different.

Both sexes have the pale basal abdominal spots and blotch—in all probability a group character.

♂. *Head* much broader (3 : 2) than deep. Eyes widely separated, the breadth of the frons being nearly equal to the depth of the head from the anterior ocellus to the clypeal edge. The latter straight-edged, with two minute notches medianly set apart two-fifths the length of the genal keel. Toruli high up, their upper line just above the middle of the face and nearer (3 : 4) the orbits than to one another. Eyes bare, prominent, three-fifths the depth of the head. Surface nearly smooth medianly above the toruli, the rather fine pattern becoming more marked towards the orbits and genal keel or suture. Whole face remarkably bare ; four bristles in a quadrangle on the clypeus and a minute one at each notch, two on the inner side of the genal suture, 2–3 below each torulus, and 4–6 along each orbit. Antenna, 0·7 mm. (fig. 7, *a*) ; scape (10 : 3) longer (7 : 3) than the pedicel (3 : 2) and practically


Fig. 7. *Tetrastichus radiatus*, sp. n. : *a*, antenna of ♂ ; *b*, antenna of ♀.

as long as the club, the spur excepted ; sense-organ short, about one-third the breadth. On each of the first four normal funicular joints and on the first segment of the club is a row of long tubular hairs, as follows, 10, 10, 8, 6, 5 ; there are besides one sensorium on segments one and the first of the club, and two (exceptionally three on the second) on all the others. Segments of funicle and club, 24, 33, 35, 35, 22, 22, 22, and spur about 5 ; the breadth decreases from 24 (1) to 18 (4) and 15 on the club. Labrum simple, transverse, with four bristles (2, 2) ; mandible very concave ventrally, teeth deeply separated, the upper one broad ; stipes with a longish bristle at side near palpus and another minute one near middle ; the maxillary palpus two and a half times the labial ; galea with about six strongly pustuled bristles and some twenty more on the upper flap.

*Thorax*. Pronotum with pattern moderate, little raised ; besides the usual bristle above the spiracle, there are on each side of mid line 5–6 in a posterior row and 10–12 (minute) more irregularly placed. Mesonotum with four short stout bristles (2, 2) close to the parapsidal furrows, one pair at one-fourth and the other at three-fourths

from the scutellar suture. Metanotum smooth, in some some specimens with a trace of a percurrent carina in the mid area. Propodeon smooth, median carina broad, spiracle large, broadly oval (lying forward on the anterior edge with only a short sulcus), three-fourths as long as the median carina ; one longish bristle at the edge of the spiracle anterolaterally, and one between the spiracle and the postero-lateral angle. There are no lateral folds ; at most a short spur is, in some specimens, given off from the lateral edge on each side of the mid line. Mesosternopleurae nearly all smooth, but the upper two-thirds of the prepectus show a rather coarse, slightly raised pattern.

*Wings*. Fore wings, length, 0·9 mm., about two and a quarter times as long as broad ; one bristle on submarginal, and below the submarginal cell 2–3 minute bristles near the base and 3–4 at the apex ; marginal vein stout, with about nine bristles at the edge and the same number below, but with up to 11 on the dorsal surface ; radius with 2–3 bristles, both above and below. Hind wings, 0·7 mm.

*Legs*. Fore tibial spur short and feeble ; two short spurs on the side of the first tarsal joint anteriorly ; 8–9 spines in comb of hind tibiae ; first joint in all the tarsi short and in the following ratio : (i), 15, 20, 15, 25 ; (ii), 15, 22, 17, 25 ; (iii) 15, 20, 20, 25.

*Abdomen*. Dorsal surface smooth (especially antero-medianly), but distinctly raised at the sides narrowly and on the overlapping portions of each tergite (pleurae). Tergites 1–5 have 2–3 bristles on the pleurae ; 1 is bare dorsally ; 2 has two bristles at each side ; 3, 4, and 5 have a posterior row of about 8–10 bristles ; 6 shows 4–5 between the spiracles and two outside each spiracle posteriorly, while there are two more on each detached overlap. The stylet is one-third broader than long and bears four long bristles ; between the stylets two bristles. The sternites (except the first) bear two bristles medianly (1, 1). The penis is very elongate, and even when retracted is three-fifths the abdomen in length, while the flattened tip is over one-fourth.

*Length*, about 1·1 mm. ; alar expanse, about 2 mm.

♀. *Head* broader than long (8 : 6), but hardly so broad as in the ♂. Face (4 : 3) with 7–8 bristles along each orbit and 8–10 more before the mid-line. Toruli at one-third from mouth-edge to the anterior ocellus. Antenna (fig. 7, *b*) 0·7 mm. ; scape (7 : 2) longer (13 : 6) than the pedicel (2 : 1) and one-fifth longer than the club not counting the spur ; pedicel and first funicular subequal (32 : 29) in length and half as broad as long ; funicle and club in ratio, 29, 25, 22, 16, 16, 24 ; the breadth of the three funicular joints 15, 17, 20, and of the club sutures 30, 24 ; sensoria 4, 5, 7, 7–8, 11, 6. Maxillary palpi over twice (9 : 4) the labial.

*Thorax*. On the pronotum the scattered minute bristles before the posterior row number about 20 on each side. Propodeon smooth near the keel, but rougher, with large, slightly raised pattern, on outer half and round the spiracle.

*Wings*. Fore wings (7 : 3), length just over 1 mm. ; fringing bristles of marginal as in ♂, but up to 14 on the dorsal surface of vein itself. The stalk of the radius bears three bristles, and there may be one or more as well on the head. Hind wings, length 0·8 mm.

*Legs*. Tarsal joints in ratio : (i), 15, 20, 18, 30 ; (ii), 20, 25, 20, 30 ; (iii), 20, 25, 23, 30.

*Abdomen*. The pale, smooth, weakly chitinised dorsal area extends over four tergites medianly. There are more bristles in the posterior rows on tergites 3–6. Tergite 5 is nearly twice as long as 6. Posterior row on 6 with about 14 bristles. Between the stylets on tergite 7 are four bristles (2, 2) and four more anteriorly,

while on the posterior edge are about six minute bristles. Ovipositor barely protruding ; the free portion of the sheath about one-fourth of the base. Sternites weakly chitinised.

*Length,* 1·3 mm. ; alar expanse, 2·6 mm.

*Type* ♂ in the British Museum ; one of a series (♂,.♀).

Bred from *Euphalerus citri* (nymph) attacking lemon leaves.

INDIA : Lyallpur, Punjab, 2.i.1921 (*D. Bakai*).

Transmitted to the Imperial Bureau of Entomology for identification by Mr. Afzal Husain, Government Entomologist, Punjab.

# SOME INJURIOUS NEOTROPICAL WEEVILS (CURCULIONIDAE).

By Guy A. K. Marshall, C.M.G., D.Sc.

(Plates I & II.)

## Subfamily Otiorrhynchinae.

### Genus **Apodrosus,** nov.

The species for which this genus is proposed is closely allied to *Polydrusus*, Germ., and agrees with it in all its more salient characteristics ; but it differs from all the species of that genus known to me in the following points :—The head bears a long, deep median furrow ; the epistome forms a large bare smooth triangular area, which is well defined and in no way impressed, but even slightly convex ; the elytra have a prominent posterior callus, and the ninth and tenth striae coalesce in the middle for one-third of their length.

Genotype, *Apodrosus wolcotti*, sp. n.

**Apodrosus wolcotti,** sp. n. (Plate i, fig. 7).

♂♀. Integument black or dark piceous, fairly closely covered above with small, near circular, pinkish buff scales having a distinct coppery sheen ; the elytra sometimes with an indefinite narrow band of dark brown scales behind the middle between striae 3 and 6 ; the lower surface with coppery grey scaling along the sides of the sternum and venter, the median area with sparse short curved pale squamiform setae.

*Head* very finely and obliquely aciculate ; the forehead quite flat, its least breadth about equal to the length of an eye, and with a deep median furrow extending backwards to the level of the hind margins of the eyes ; the eyes elongate, longitudinal, prominent, coarsely facetted and with their greatest depth behind the middle. *Rostrum* comparatively long, a little longer than the head and much longer than its own basal width, and strongly dilated in the apical half ; the dorsum very convex transversely, finely rugulose, with a broad median furrow in the basal half ; the epistome comparative large, not at all impressed, but slightly convex, and shallowly punctate ; the scrobes very deep, narrow and remote from the eyes. *Antennae* testaceous brown, long and slender, the distal joints of the funicle much longer than broad. *Prothorax* transverse, subparallel-sided or very slightly widening from the base to beyond the middle, and then rapidly narrowing to the apex ; the dorsum with coarse subconfluent shallow punctures, which are partly concealed by the scaling, and with a broad shallow transverse depression near the apex ; the scaling not so dense as to conceal the integument entirely, and interspersed with recumbent spatulate setae ; the prosternum longer than usual in front of the coxae. *Scutellum* with sparse minute setae. *Elytra* broadly ovate in ♀, much narrower in ♂, much wider at the shoulders than the prothorax, with a prominent posterior callus at the apex of interval five ; the striae containing large shallow punctures, the intervals (when not abraded) much broader than the striae and plane or slightly convex, each bearing a row of short curved spatulate setae. *Wings* fully developed. *Legs* piceous, with rather sparse scales and spatulate setae ; the femora unarmed.

*Length*, 3·5–5 mm. ; breadth, 1·6–2·4 mm.

Porto Rico : Rio Piedras, iv. 1921 (*G. N. Wolcott*).

Described from ten specimens.

**Diaprepes capsicalis,** sp. nov.

♂♀. Integument black or piceous, fairly densely clothed above and below with brown or brownish grey scaling, often with a coppery reflexion ; the elytra with a pale dot about the middle of interval five.

*Head* with the eyes much longer than broad, flattened, the space between them narrower than that between the antennae. *Rostrum* much longer than broad, the dorsum somewhat flattened in the middle, the edges of the flattened area converging behind and sometimes feebly costate, but always vanishing well before the base; an elongate impression on each side in front of the eye. *Antennae* with the scape scarcely reaching the base of the eye; the funicle with joint 2 distinctly longer than 1, the apical joints much longer than broad and clavate. *Prothorax* transverse, with the sides parallel (♂) or slightly converging (♀) from the base to beyond the middle, then narrowing rapidly to the apex; the postocular vibrissae consisting of only three or four very short setae and sometimes apparently absent; the dorsum with rugose shallow confluent punctures, slightly flattened on the basal half of the disk, and with a very shallow median furrow on the anterior half; the scaling slightly less dense on the dorsum than on the pleurae. *Elytra* ovate, much broader at the shoulders than the prothorax, almost parallel-sided to beyond the middle, acuminate behind, with the apices usually slightly divergent, the shoulders rounded obtusangular, the basal margin between the scutellum and shoulder gently curved; the dorsal profile rising gently from the base and highest far behind the middle, the posterior declivity with a slope of about 70°; the punctures rather coarse, the rows fairly regular in the basal half in the ♀, less so in the ♂, and mostly irregular behind the middle in both sexes; the scales very small, nearly circular and fairly closely placed, interspersed with minute recumbent setae, which are longer and form regular rows posteriorly; the punctures each containing a small, usually greenish, scale. *Legs* densely squamose and with numerous subrecumbent stout white setae; all the tibiae with widely spaced denticles on the inner edge.

*Length*, 8–12 mm.; breadth, 3·25–5·5 mm.

Porto Rico: Rio Piedras, vii. 1917 (*R. T. Cotton*).

Described from 24 specimens.

In spite of the evanescent prothoracic vibrissae, this distinct species is placed in *Diaprepes* rather than in *Exophthalmodes* on account of the second joint of the funicle being distinctly longer than the first, and because the mentum bears only four setae in a transverse row.

Mr. Wolcott states that the adult of this species has been observed feeding on the leaves of pepper (*Capsicum*).

**Exophthalmodes roseipes,** Chev.

Chevrolat (Bull. Soc. Ent. France (5), vi, 1876, p. ccxxvii) described this species as a *Pachnaeus*, but it is unquestionably an *Exophthalmodes*.

Mr. G. N. Wolcott notes that the adults attack the leaves of cotton at Isabella, Porto Rico, but states that the species is more abundant on citrus trees.

**Lachnopus coffeae,** sp. nov. (Plate i, fig. 8).

♂♀. Integument piceous, with the legs, antennae and apex of the rostrum reddish brown; clothed above and below with small, convex, shiny, subcircular or very shortly ovate, white scales, which are mostly not contiguous, but more closely set here and there, leaving much of the integument exposed; the median area of the prothorax with very few scales; and on each side of it a more condensed but indefinite stripe, and a similar one just above the coxae, which continues across the mesosternum and broadens out on the metasternum; the elytra usually with three very irregular transverse subdenuded patches, sub-basal, median and postmedian, and sometimes a small one on the declivity.

Form very narrowly ovate. *Head* with sparse squamigerous punctures behind the eyes, those on the forehead being more numerous, and with a shallow median

fovea. *Rostrum* about as long as the head, slightly narrowed from the base to the middle, markedly dilated at the apex, and the dorsal outline rather strongly curved ; fairly closely set with non-contiguous scales, and with a short median furrow between the antennae ; the rostrum of ♀ a little shorter and stouter than that of ♂. *Antennae* with the scape reaching or slightly exceeding the hind margin of the eye ; joint 1 of the funicle a little longer but much stouter than 2, 3 shorter than 2 and longer than 4, and 4–7 subequal. *Prothorax* slightly broader than long, the sides very rounded, distinctly narrowed but not constricted in front, and the basal margin subtruncate and somewhat raised in the middle ; the dorsum rather coarsely and more or less confluently punctate, the dorsal profile almost flat. *Elytra* very narrowly ovate, much broader than the thorax at the shoulders, which are roundly rectangular, with the sides subparallel to the middle, and the apices separately and obtusely pointed ; the shallow striae with large quadrate punctures, which are as broad as the smooth intervals on the disk, but become much smaller behind ; each puncture with a minute setae and a few similar ones on the intervals. *Legs* thinly clothed with oval white scales and recumbent setae ; all the tibiae finely denticulate internally, the hind pair of the ♂ with the inner face flattened and clothed with long silky hairs.

*Length*, 5·5–6·25 mm. ; breadth, 1·8–2 mm.

Porto Rico : Rio Piedras, xi.1921 (*G. N. Wolcott, F. Sein*) ; Caguas (*G. N. Wolcott*).

Described from nine specimens.

**Lachnopus coffeae montanus,** subsp. nov.

This upland race differs from the typical coast form in being somewhat larger and having the legs markedly paler ; the scales on the upper surface are much sparser

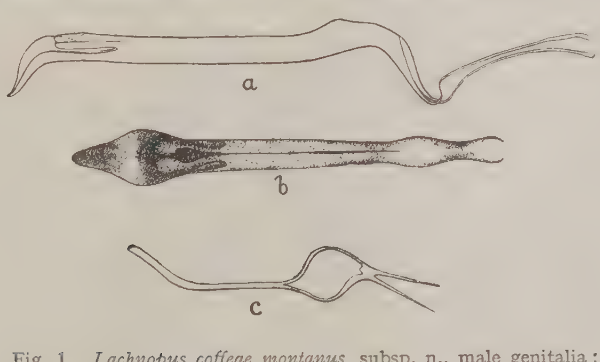


Fig. 1. *Lachnopus coffeae montanus*, subsp. n., male genitalia : *a*, lateral view of median lobe ; *b*, dorsal view of same ; *c*, tegmen.

and more evenly distributed, and they are also rather smaller and more nearly circular ; most of them being very pale blue or bluish white ; on the other hand the stripe of white scaling along the side of the sternum is much denser and more sharply defined. There appears, however, to be no reliable structural difference either in the external characters or in the male genitalia.

*Length*, 6–6·75 mm. ; breadth, 2–2·5 mm.

Porto Rico : Yauco (mountains), 16.vi.1921 (*G. N. Wolcott*).

Described from two males.

The adults of both forms are recorded as feeding on the young leaves of coffee.

The form of the male aedoeagus is shown in fig. 1 ; the uneverted sac is contained entirely within the median lobe and is covered with asperities for about one-third

of its length ; the transfer apparatus is in the form of a small bent chitinous rod ; the struts of the median lobe are comparatively short and unusually slender and delicate, breaking off very readily in dissection. The vagina of the female is lightly and irregularly chitinised ; the palps are conspicuous (0·26 mm. long), and each bears one or two short setae and two that are about three-fourths the length of the palp ; below each palp is a prominence bearing a seta nearly half as long again as the palp, and two very short ones. The bursa copulatrix is about as long as the vagina and twice as long as broad, very lightly and indefinitely chitinised in the anterior (proximal) half, and with irregular darker chitinous stripes in the posterior third.

## Subfamily Liparinae.

**Anchonus suillus,** F. (Plate i, fig. 3).

Mr. G. N. Wolcott states that specimens of this species were found in a rotten stump of a castor-oil plant at Rio Piedras, Porto Rico. The attack was probably a secondary one, but as very little is known as to the habits of the species of this genus, it is perhaps worth recording.

The Cuban specimens examined differ only in having a trace of a median costa on the pronotum, which is not likely to be a reliable distinction.

## Subfamily Cholinae.

**Cholus wattsi,** sp. nov. (Plate i, fig. 5).

♂♀. Integument black, thinly clothed above and below with minute hair-like brownish grey scales, with the following markings of much larger narrow white scales : a narrow, rather irregular stripe on each side of the prothorax, and a similar short obliquely-transverse lateral band outside each stripe and uniting with it a little behind the middle ; the elytra with three similar narrow transverse bands (often more or less interrupted), the first near the base, the second at the middle, and the third about half-way between the middle and the apex ; the first runs obliquely from the scutellum to the lateral margin a little in front of the hind coxa, and at its inner end continues along the side of the scutellum and for a short distance along the suture ; the second extends from the suture to stria 8, curving slightly forwards at the side and almost, or quite, uniting with the first ; the third extends to stria 8 or 9 ; between the second and third there are usually irregular white marks along the suture.

*Head* with scattered shallow punctures on the vertex, the forehead flattened and with coarser longitudinally confluent punctures, and the postocular area with a number of low irregular curved ridges. *Rostrum* (across the curve) as long as the front femur in both sexes, the apical area strongly dilated and somewhat flattened ; in the ♂, subcarinate in the basal half, with very coarse and longitudinally confluent punctures near the base, thence strongly and closely punctate to the antennae and with fine sparse punctures on the apical area ; in the ♀, finely and sparsely punctate throughout, except close to the base, and with no trace of a median carina. *Antennae* black ; joint one of the funicle a little shorter than 2 and 3, 4-6 as long as broad and bead-like, 7 longer and subconical. *Prothorax* much broader than long, widest not far from the base and very rapidly narrowed in front, the sides being strongly rounded ; the gular margin very feebly sinuate and with a dense fringe of short fulvous setae ; the prosternum tuberculate between the coxae ; the dorsum closely set with low shiny granules, those between the longitudinal stripes being much flattened and often confluent, the lateral ones more convex. *Scutellum* cordiform, the anterior two-thirds flattened and sloping forwards, the front margin shallowly sinuate in the middle, the surface shallowly punctate and with a few short recumbent setae at the sides and apex. *Elytra* very broadly ovate and obtusely rounded at the apex, with regular rows of shallow punctures separated by transverse shining granules, each of which bears a short seta on its posterior slope ; the intervals each bearing a more or less regular

row of round flattened shiny granules, the spaces between the granules dull and thinly clothed with minute hair-like scales; the posterior margin not denticulate. *Legs* with numerous short recumbent pale setae; the femora all with a sharp tooth in both sexes and closely set with flattened, transversely confluent shiny granules; the tibiae with shallow, longitudinally confluent punctures, all uncinate and mucronate at the apex in both sexes, and with a sharp median tooth on the inner edge of the front pair in the ♂ only. *Sternum* set with flattened granules; the intercoxal process of the mesosternum not tuberculate and twice as broad as that of the prosternum.

*Length*, 16·5–20·5 mm.; breadth, 8–10·5 mm.

LESSER ANTILLES: Grenada (*H. A. Ballou*).

Described from 21 specimens.

The nearest allies of this insect are the Brazilian species, *C. undulatus*, Gyl., and *C. parcus*, Fhs., especially the latter, which is very similar in its general form and sculpturing; but it lacks the thoracic markings and the transverse bands on the elytra, when present, are very indefinite and irregular, the basal one lying actually on the basal margin. But both these species differ, *inter alia*, in the following structural characters: the prosternum is not tuberculate between the coxae; the front femora bear no tooth in either sex; the front tibiae in the ♂ have no median internal tooth; and the front coxae in the same sex each bear a stout spur.

The species is dedicated to Sir Francis Watts, K.C.M.G., Commissioner of the Imperial Department of Agriculture for the West Indies, who forwarded specimens with the information that the insect was doing appreciable damage to pineapples in Grenada.

I am indebted to Mr. H. A. Ballou, Entomologist to the Department, for examples of the larvae (fig. 2) and for the following interesting notes on the species.

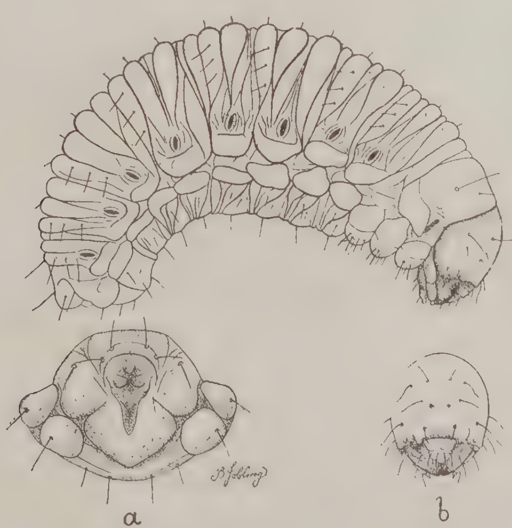



Fig. 2. Larva of *Cholus wattsi*, sp. n.; *a*, posterior view of anal segment; *b*, dorsal view of head.

"The pineapple weevil was discovered by Mr. R. O. Williams, Agricultural Superintendent, in May 1920, on a peasant holding at Grantons, St. George's,

Grenada. On the 1st May 1921, I visited the pineapples, where the weevil had been found, with Mr. Williams and Mr. Donovan, and together we got additional specimens and made observations which seem to give the main points as to the manner of attack by this insect.

"The pineapples had been planted some years ago, but for about three years had had no attention. The plants had been overgrown with weeds and bush, which had been cut, over a part of the holding, a short time before our visit. Many of the pines grew in the shade of trees of various kinds. Pineapples belonging to other peasants, where clean cultivation was practised, were examined, but no weevils or signs of their attacks were seen. It would seem a safe statement to make that this insect is not likely to attack pineapples when they are grown under conditions of clean cultivation, in open fields away from the influence of shade. This opinion, however, is based on the conditions observed on only one visit to this infested patch.

"The injury to the pine (Plate ii) is largely the result of the feeding of the larvae, in the fruit stalk, in the centre of the developing fruit and in the crown. The feeding punctures of the adults in the developing fruit, the fruit-suckers and the crown, and excavations apparently made by the female for egg-laying also cause considerable injury. The adult weevils, in captivity, feed on the fruit, the stalk, the crown, and the leaves of the base of the suckers, as well as perforating the leaves of the crown and suckers. The vegetative portions of the plants, roots, root-stock, stem and leaves are not attacked.

"The feeding punctures made by the adults are small and circular, and those in the stalk and fruit may be as deep as the length of the rostrum to the eyes. The excavations believed to be made for the reception of the eggs are shallow and oval, and seem to be dug out by means of the mandibles. The excavating of these cavities and the egg-laying have not been observed.

"From observations in the field it appears that the eggs are laid in the flower-stalk, and the larva makes its way either up or down. Stalks were found in which the work of the larvae was to be seen from the base of the fruit to the base of the stalk, but no cases were found in which the larva had penetrated into the centre of the plant ; though several instances were observed in which the larva had gone up into the fruit, and in one case the base of the crown was eaten out.

"The feeding punctures of the adults often completely spoil the fruit. A badly attacked pine will show gummy exudations and will be deformed and undersized. Attacked pines often lose their crowns, even though the pine itself is comparatively uninjured. The greatest damage appears to result from attacks on the fruit-stalk, which is often so badly eaten that it breaks down with the weight of the fruit.

"The control of this pest appears to lie in good cultivation and the absence of shade. The pineapples should be planted in straight and regular rows, with sufficient distances between the rows to allow of clean weeding ; no bush should be allowed to grow amongst them.

"If pines that have been properly planted and carefully tended should be attacked by the weevil, it should be possible to check such an attack without much loss by collecting the weevils, which may be found hiding in the axils of the leaves, and by cutting out and destroying any infested fruit, taking care to cut the flower-stalk at the very base in order to make sure of removing any larva that may be there."

### Subfamily Cryptorhynchinae.

**Conotrachelus psidii,** sp. n. (Plate i, fig. 1).

♂♀. Integument dark piceous ; the pronotum with dense fulvous scaling, and usually with a large indefinite darker triangular patch in the middle of the base, caused by the scaling being there much thinner, so that the integument shows through ; the elytra with similar dense fulvous scaling, and with a large subquadrate, ill-defined

dark discal patch extending from the base to the top of the declivity and outwardly as far as stria 4, the scaling there being dark brown slightly variegated with grey; the sternum with rather thin fulvous scaling laterally and denser paler scales in the middle; the venter with very sparse whitish setiform scales.

*Head* with coarse confluent punctation that is not obscured by the scaling, the intervals between the punctures becoming sharp and prominent on the forehead; the scales fulvous and narrow, becoming noticeably broader on the middle line; at the junction with the rostrum a shallow transverse depression containing a deep median fovea, and a faint broad impression above each eye. *Rostrum* stout, cylindrical, moderately curved, longer than the prothorax in both sexes, slightly dilated at the apex, rugosely punctate and five-carinate a far as the antennae, the outer carinae being less distinct and undulating and the apical area closely punctate in both sexes. *Antennae* inserted at about one-fourth from the apex in the ♂ and about one-third in the ♀; joint 2 of the funicle a little shorter than 1. *Prothorax* subconical, transverse, gradually narrowed from the base to beyond the middle, then more rapidly so, the sides gently rounded and shallowly constricted near the apex; the basal margin shallowly bisinuate, the median dorsal lobe broadly subtruncate at the apex; the dorsum finely coriaceous, unevenly set with large punctures, which are deepest and most numerous in the dark basal triangle and towards the sides; a low boss-like elevation in the middle of the disk, from the top of which a low carina runs to the front margin; the scales narrow and elongate, interspersed on the fulvous area with white scale-like recumbent setae, which are blackish on the dark area. *Scutellum* oval, longer than broad, with confluent shallow punctation and fulvous setiform scales. *Elytra* broad, subtriangular, broadest at the roundly angulate shoulders, with regular rows of large distant punctures, the distances between them being as long as the punctures themselves, which become much shallower on the posterior declivity; the intervals broader than the punctures and finely rugulose, 3, 5, 7 and 9 being carinate and the others flat; the carina on 3 much higher than the others and deeply interrupted before the middle and more broadly so behind the middle, the other carinae complete; the scales on the dark area rather narrower and less dense than on the fulvous parts, the intervals with a row of recumbent scale-like white setae, and each puncture containing a white seta. *Legs* rugulose, with fairly dense fulvous scales intermingled with white setae; the femora each with a single stout tooth; the front and hind tibiae rather sharply angulate externally at the apex; the tarsal claws with a rather long sharp tooth. *Sternum*: the mesosternum hollowed and with a low prominence on each side between the middle coxae, the side-pieces finely aciculate, opaque, and closely and coarsely punctate; the metasternum shiny, with numerous fine punctures and scattered large ones, and with a strong oblique ridge between the mid and hind coxae. *Venter* very shallowly punctate, except at the base of the first and apex of the last visible ventrite, the latter being longer and flatter in the ♂ than in the ♀.

*Length*, 5·75–7 mm.; breadth, 3·5–4 mm.

BRAZIL: Bahia (*G. Bondar*).

Described from four specimens.

This species is very closely allied to *C. dimidiatus*, Champ., from Central America, but the latter differs in the following particulars: —the mesosternum is quite flat between the middle coxae; the metasternum is as coarsely and closely punctate as the mesosternum; the middle portion of the carina on interval three is much less elevated and the carina on five is evanescent on its basal third; the shoulders are less sharply angulated, etc.

Dr. Bondar has found this insect attacking the fruits of the guava (*Psidium guayava*), though the nature of the injury is not indicated.

**Coelosternus granicollis,** Pierce (1916).

Mr. G. Bondar states that this species attacks the stems of cassava (*Manihot utilissima*) at Bahia in Brazil. The species was described (with a good figure) from four specimens found alive in quarantine in Washington, D.C., in cassava stems from an unspecified locality in Brazil.

Mr. Pierce uses the generic name *Leiomerus*, Boh., for his species, rejecting *Coelosternus*, Schh., on the ground that the name was preoccupied by Sahlberg. It is true that the latter author described a species of *Coelosternus* shortly before Schönherr's "Dispositio methodica" appeared, for, as he clearly explains, he considered it desirable to follow Schönherr's new classification (with which he was obviously acquainted) even though it had not actually been published; and moreover he takes care to cite Schönherr as the author of the name of his insect. Sahlberg did not describe the genus *Coelosternus*, nor did he cite a type, and there can be no scientific justification for using the name otherwise than in the sense clearly defined by Schönherr. Further, the name *Leiomerus* was not established by Boheman, but was a MS. name of Chevrolat's which Schönherr rejected, merely quoting it in the synonymy of *Coelosternus glabrirostris*. The name should therefore be attributed to Pierce and sinks as a synonym of *Coelosternus*, Schh.

## Subfamily Zygopinae.

**Piazurus papayanus,** sp. nov. (Plate i, fig. 2).

♂♀. Integument black or piceous black, rather thinly clothed with brown and grey setiform scaling, the elytra with a few small indefinite patches of suberect black scales principally on intervals 2–4; the lower surface with more sparse pale setiform scales.

*Head* with a few coarse punctures on the vertex and a line of single scales between the eyes. *Rostrum* strongly narrowed from the base to the middle and thence very slightly widening to the apex; the basal third very convex transversely, closely and strongly punctate, and with a low median ridge; the distal portion more flattened dorso-ventrally and very minutely and sparsely punctate. *Antennae* red-brown; joint 2 of the funicle nearly twice as long as 1, 3 equal to 4, and 5, 6 and 7 bead-like. *Prothorax* conical, a little shorter than its basal width, the sides straight and not constricted anteriorly; the basal margin strongly bisinuate and its median lobe shallowly sinuate; the dorsum with a very high tubercular elevation on the median line in front of the middle (Pl. i, fig. 2, *a*) and a very faint median costa running from it to the base; the dorsal sculpture mainly hidden by the scaling, but consisting of unevenly distributed minute punctures, which are denser towards the sides, and a few much larger punctures, which are mostly confined to the anterior half and especially on the slopes of the prominence; the supracoxal carina distinct. *Scutellum* ovate, with minute shallow punctation and very short setae. *Elytra* ovate, broadly rounded behind, with the shoulders prominent, and the dorsal outline strongly convex; the deep striae containing large punctures which gradually become evanescent behind, the septa between them often subgranular, and each puncture with a horizontal setiform scale projecting from its anterior edge; the intervals rather broader than the striae, with numerous very closely placed and usually transverse granules, which become smaller behind but are absent on the basal half of intervals 7–9, and a very low transverse elevation not far from the base on intervals 2–4; each interval with a single row of short recumbent setae, which are not easily distinguished from the scaling. *Legs* finely punctate and rather thinly clothed with pale narrow scales; the anterior pairs of femora not toothed; the hind tibiae without an ante-apical spine on the inner edge. *Venter* with a large ∩-shaped impression in the middle of the first visible ventrite.

*Length*, 9·5–10·25 mm.; breadth, 4·75–6 mm.

Brazil: Bahia (*G. Bondar*).

Described from four specimens.

The larvae of this insect are stated by Mr. Bondar to bore in the leaf-stems of the papaw (*Carica papaya*).

This species belongs to Dr. Heller's subgenus *Pseudopiazurus* (1906) and is very closely allied to *P. obesus*, Boh., which, however, has the granules on the elytra rather widely spaced and nearly round, and the scales are appreciably longer; the thoracic prominence is a little lower; and in the male genitalia the struts of the median lobe are broadly spatulate at the apex, whereas in *P. papayanus* they are almost linear.

In the present species the median lobe of the male aedoeagus (fig. 3) is not in the form of a chitinous tube, but is entirely membranous above, the ventral portion forming a broad subquadrate shovel-shaped chitinous trough, the apex of which is broadly truncate and bears on its lower surface a large patch of long hairs on each side; the median struts are formed as a continuous extension of the thickened edges

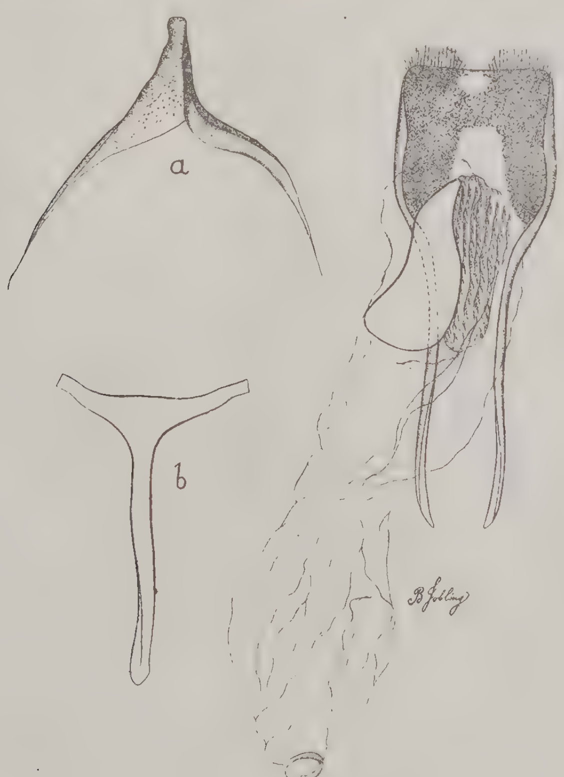



Fig. 3. *Piazurus papayanus*, sp. n., male genitalia: *a*, tegmen; *b*, spiculum.

of the median lobe, and are rather more than half as long again as the lobe itself, being only slightly widened dorsoventrally at the apex. The uneverted sac is very broad and extends for nearly half its length beyond the ends of the median struts; the portion adjoining the median lobe contains a large chitinous plate (0·5 mm. long) shaped like a bird's wing, broadest (0·2 mm.) near its internal end and

rapidly narrowing to a point in its distal half ; at the terminal (functional) orifice there is a complete and conspicuous chitinous ring (0·12 mm. across). The tegmen does not form a ring, being **Y**-shaped and somewhat asymmetrical.

In the female genital tube (fig. 4) the vagina is comparatively short and quite membranous ; the palps are elongate (0·1 mm.) and bear an oblique row of short unequal hairs at the apex, the supporting strips of chitin being 0·33 mm. long with a maximum width of 0·06 mm. The bursa copulatrix is four times as long as the

Fig. 4. *Piazurus papayanus*, sp. n., female genitalia : *a*, tergite 8 ; *b*, ventrite 8.

vagina (approximately 2·5 mm.), formed of thicker membrane, and contains an elongate rod of strong chitin (0·88 × 0·07 mm.). The duct to the spermatheca is unusually short, being not much longer than the spermatheca itself, which has a very complicated shape (fig. 4) and a comparatively enormous retort-shaped accessory gland (about 0·75 mm. long).

The species referable to the subgenus *Pseudopiazurus* may be distinguished by the following characters :—

1 (6). Hind tibiae with a sharp tooth on the inner edge above the apex.
2 (3). Second visible ventrite with a sharp elevated tubercle in the middle of the basal margin projecting obliquely forwards.. .. .. .. *spiniventris*, sp. n.*
3 (2). Second visible ventrite normal.
4 (5). Elytra with a conspicuous prominence on interval three near the base, and intervals two and three costate for a short distance behind the middle; pronotum with a sharp elevation before the middle, the basal half without large punctures.. .. .. ..*defector*, Boh.
5 (4). Elytra with all the intervals of even height; pronotum without any elevation and with a number of large punctures in the basal half *centraliamericanus*, Heller.
6 (1). Hind tibiae sharply angulate internally at the apex, but with no tooth above the apex.
7 (8). Elytra with very numerous, closely placed, transverse granules on the intervals .. .. .. .. .. .. .. *papayanus*, sp. n.
8 (7). Elytra with fewer, more widely spaced and almost rounded granules *obesus*, Boh.

**Lechriops psidii,** sp. nov.

♂♀. Integument red-brown; the head with a dense edging of pale buff scales between and behind the eyes; the prothorax clothed with rather sparse narrow brownish-yellow scales, mostly transverse in position and leaving much of the integument exposed, a few blackish ones on the lateral slopes of the median elevation, a median stripe of dense broad white scales in the posterior half, a few broad yellowish-white scales in the middle of the front margin and a few on each side near that margin; the elytra fairly densely covered with mingled pale buff and whitish scales, and with an ill-defined curved dark transverse band about the middle between striae 1 and 8, which is deepest on interval three and rapidly narrows outwards to a point on interval eight; a few blackish scales on the basal half of intervals three and five, and a few more behind the middle on two, four, five, six and eight the mesosternum, metasternum and abdomen uniformly covered with large subcontiguous white scales.

*Head* with the interocular space a little broader than the widest part of the scape. *Rostrum* gradually narrowed from the base to the antennae, which are inserted a little behind the middle in both sexes, thence parallel-sided and somewhat dilated again at the apex; the basal area very convex transversely, opaque, shallowly punctate, thinly squamose, and with a smooth median carina in both sexes; the apical area with strong separated punctures in the ♂, with a shiny median line and somewhat opaque at the sides; in the ♀, shiny throughout and with much finer

* **Piazurus spiniventris,** sp. n.—♂♀. The description of *P. papayanus* applies to this species except in the following particulars :—*Prothorax* with the prominence very much lower and with a number of coarse punctures on the basal half of the disk; the supracoxal carina obsolescent. *Scutellum* with the setiform scales as long as those on the elytra. *Elytra* without the patches of black scaling; the scales distinctly longer, especially along the suture; the punctures much larger, oblong, and not diminishing behind until quite close to the apex; the intervals not broader than the striae, with much larger, less numerous, but closely set and somewhat flattened granules, and with no transverse elevation near the base. *Legs*: the hind tibiae armed with a very long oblique sharp spine at one-fourth from the apex on the inner edge. *Venter* with the arch-shaped impression on the first visible ventrite much broader and deeper; the next ventrite with a sharp, obliquely prominent tubercle in the middle of its base in both sexes; the last visible ventrite with its apical margin very broadly and deeply sinuate in ♀ and shallowly bisinuate in ♂. *Length*, 10·5–11 mm.; breadth, 5·5–5·75 mm.—Brazil: Ega, R. Amazon (*H. W. Bates*). Described from three specimens.

punctures. *Antennae* with joint 2 of the funicle longer than 1, as long as 3–5 together. *Prothorax* much broader than long, gradually narrowed from the base to beyond the middle and then more abruptly to the apex, the apical margin shallowly sinuate throughout its width ; the disk with a boss-like elevation in the middle, so that the dorsal outline is extremely convex, with the greatest height about the middle, but the posterior slope longer than the anterior one ; the dorsum with coarse shallow reticulate punctation, each puncture containing a scale, and without any carina. *Elytra* broadly cordate ; the striae with strong deep punctures, each containing a scale ; the intervals not broader than the striae and subcostate on the disk, the suture being shallowly depressed on the basal half ; the scales elliptical, much smaller than those on the pronotum and becoming shorter behind. *Legs* testaceous, the femora with dense white scaling, the tibiae with thinner hair-like scales ; the femora neither toothed nor sulcate beneath, the posterior pairs only with a faint carina on the external face. *Sternum* with the rostral canal not exceeding the front coxae, which are not tuberculate ; the mesosternum almost perpendicular and not excavated, the mesepimera slightly ascending.

*Length*, 2 mm. ; breadth, 0·9 mm.

Porto Rico : Mayaguez, 1914 (*R. H. Van Zwalenburg*).

Described from a pair.

Faust erected his genus *Eulechriops* (1896) for species of *Lechriops* with no tooth or external carina on the femora, but these characters are not interdependent, and the present species has distinct traces of the carinae without having the teeth. Champion has described a species in similar case as *Eulechriops squamulatus*, but it is very distinct from *L. psidii*, having the rostral furrow extending to the metasternum, no pronotal prominence, the two basal joints of the funicle equal, etc. The only other species known to me in which the mesosternal excavation is wanting are *Eulechriops scutulatus*, Champ., and *E. coruscus*, Champ., but these are very differently coloured insects, being black with well-defined patches of white scaling, the femora are sulcate beneath, joint 2 of the funicle shorter than 1, the pronotum has no prominence, etc.

Mr. Wolcott states that the larvae of this weevil feed on the fruits of the guava (*Psidium guayava*), which shrivel up as a result of their attacks.

## Subfamily Baridinae.

**Ampeloglypter cissi,** sp. nov.

♂ ♀. Colour uniform dark steel-blue above, the head, rostrum and lower surface blue-black.

*Head* minutely coriaceous, with faint scattered punctures. *Rostrum* stout, curved, as long as (♂) or longer than (♀) the head and prothorax, the antennae inserted behind the middle in both sexes ; the upper surface shiny and with sparse minute punctures in the ♀, finely aciculate in the ♂ and with stronger and longitudinally confluent punctures, the sides at the base with larger shallow aciculate punctures in both sexes. *Prothorax* broader than long, rounded at sides, widest at the base and rather abruptly tubulate in front ; the dorsal profile distinctly convex and deepest in the middle in the ♂, much flatter in the ♀ ; the dorsum minutely coriaceous and evenly set with small distant punctures. *Elytra* distinctly wider at the shoulders than the prothorax, oblong-ovate, with the humeral prominences well developed ; the striae rather deep and containing small shallow spaced punctures ; the intervals flat, extremely finely coriaceous and each with a row of minute distant punctures. *Sternum* closely and strongly punctate laterally, the punctures on the side-pieces

of the mesosternum larger and fewer than those on the metasternum. *Venter* with smaller and rather sparser punctures than on the sternum, except those on the last ventrite, which are dense.

*Length*, 2 mm. ; breadth, 1 mm.

PORTO RICO : Rio Piedras, vii.1921 (*F. Sein*).

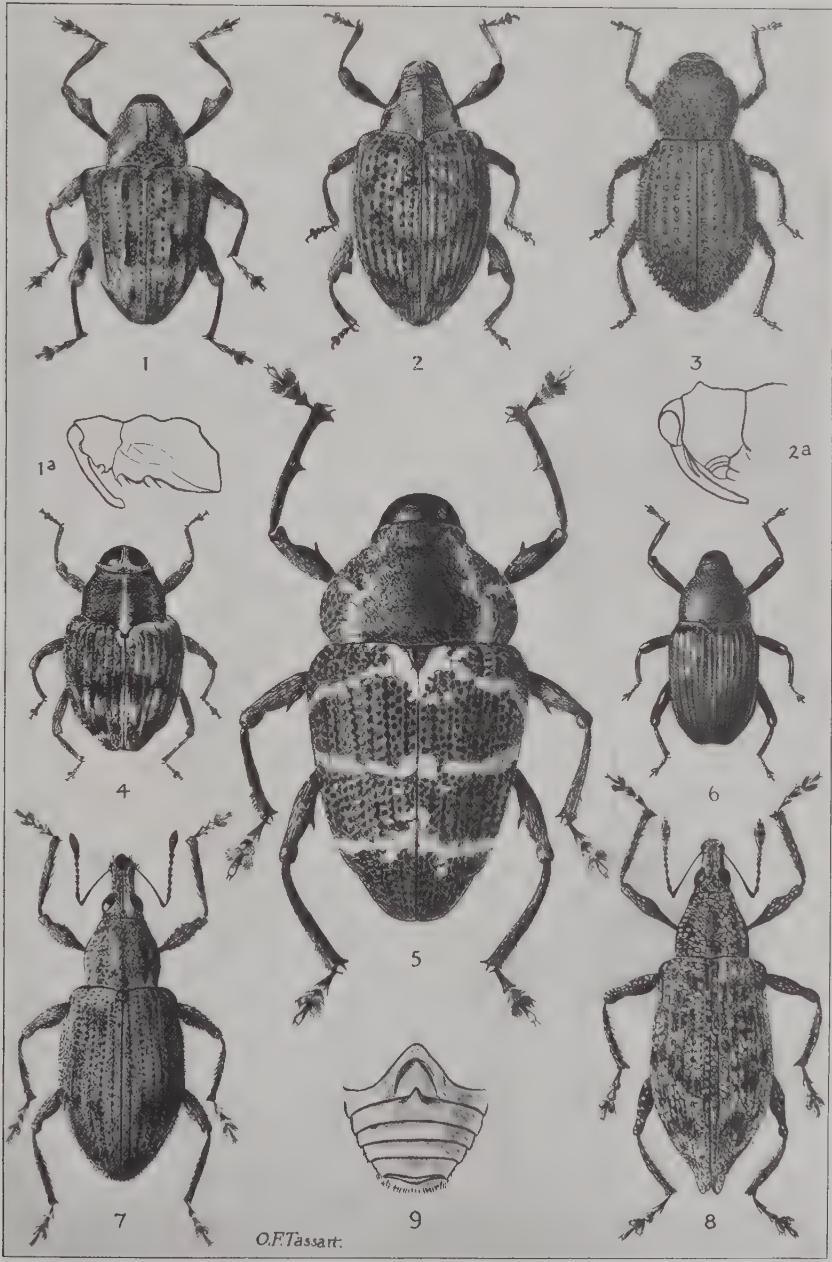
Described from three specimens.

Its small size and blue colour will distinguish this species from those that have been previously described. In general form and sculpture it most resembles the North American *A. longipennis*, Casey, but in that species the punctures on the sides of the sternum are larger and closer, being subreticulate, the antennae are inserted at the middle of the rostrum in the ♂, the last visible ventrite in the ♂ is markedly elevated in the middle, etc.

The adults are stated by Mr. Wolcott to feed on the tender shoots of *Cissus ampelopsis*.

## EXPLANATION OF PLATE I.

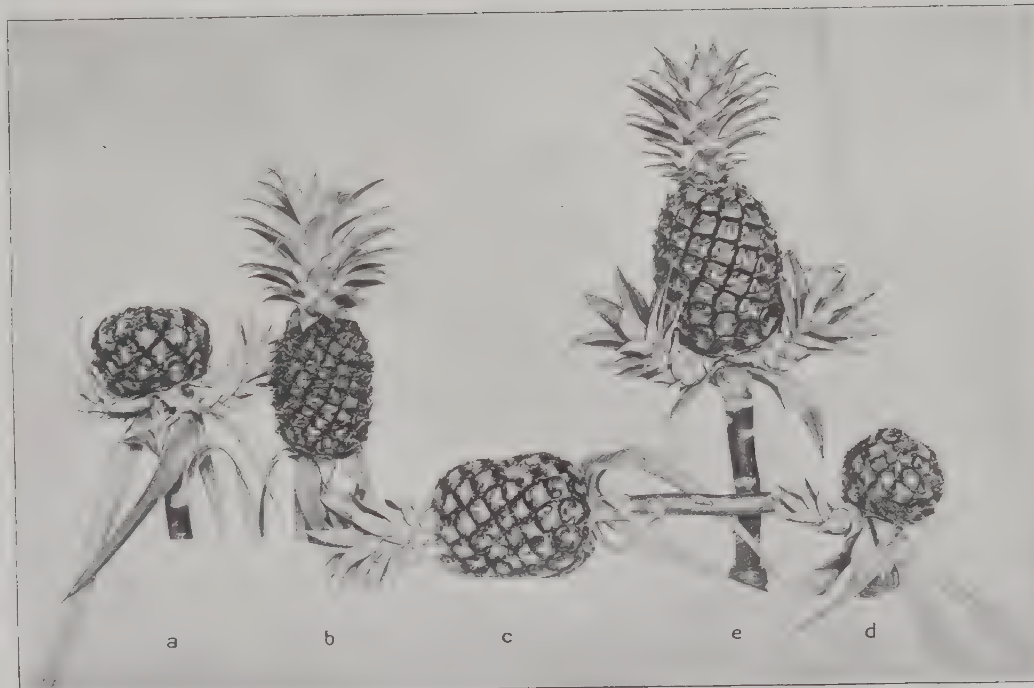
Fig. 1. *Conotrachelus psidii*, sp. n.
,, 2. *Piazurus papayanus*, sp. n.
,, 3. *Anchonus suillus*, F.
,, 4. *Lechriops psidii*, sp. n.
,, 5. *Cholus wattsi*, sp. n.
,, 6. *Ampeloglypter cissi*, sp. n.
,, 7. *Apodrosus wolcotti*, gen. et sp. n.
,, 8. *Lachnopus coffeae*, sp. n.
,, 9. *Piazurus spiniventer*, sp. n., venter.




Injurious Neotropical Weevils.

## EXPLANATION OF PLATE II.

Photograph of pineapples to show the injury done by the weevil, *Cholus wattsi*, sp. n. The only sound fruit is (*e*), which is shown for comparison ; (*a*) and (*d*) have lost their crowns, and are generally dwarfed and deformed ; (*b*) was covered all over with feeding punctures of the adults ; the oval depression on the stalk of (*c*) is believed to be an excavation in which the eggs are deposited.




Pineapples damaged by a Weevil, *Cholus wattsi* sp. n

# MOSQUITO NOTES.—III.

By F. W. Edwards.

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Contents:



## A.—On a Collection of Mosquitos from Paraguay.

The collection here described was sent for determination by Dr. K. Kertêsz to Mr. F. V. Theobald in 1911, and was passed on to the writer by Mr. Theobald in 1921. Most of the specimens were collected by Fiebrig, and these unfortunately bear no exact data. A few (including the type of *Janthinosoma paraguayensis*) were collected by Vezênyi, mostly at Asuncion in 1904. Though not large, the collection contains a high percentage of apparently undescribed forms, which are dealt with below. The holotypes of two of the new species are in the collection of the Budapest Museum, but in those cases where the species has been described from a number of cotypes, the material has been divided between the Budapest Museum and the British Museum. Since little seems to have been recorded concerning the mosquitos of Paraguay, I give first a list of all the species included in the collection.

*Megarhinus portoricensis*, v. Röder.
*Sabethes schausi*, D. & K.
*Wyeomyia* (*Phoniomyia*) *fuscipes*, sp. n.
*Psorophora* (*Psorophora*) *ciliata*, Fab. (? *tibialis*, R.-D.; ? *lynchi*, Brèthes).
,, ,, *pallescens*, sp. n. (*ciliata*, Arr.).
,, (*Janthinosoma*) *posticata*, Wied.
,, ,, *fiebrigi*, sp. n.
,, ,, *discrucians*, Walk. (*paraguayensis*, Strick.).
,, ,, *purpurascens*, sp. n.
,, (*Grabhamia*) *confinnis*, Arr.
,, ,, *varinervis*, sp. n.
*Aëdes* (*Ochlerotatus*) *stigmaticus*, sp. n.
,, ,, *albofasciatus*, Macq.
,, ,, *scapularis*, Rond.
,, ,, *serratus*, Theo.
*Taeniorhynchus* (*Taeniorhynchus*) *titillans*, Walk.
,, ,, *fasciolatus*, Arr.
*Aëdomyia squamipennis*, Arr.
*Culex coronator*, Theo.
,, *fatigans*, Wied.
*Anopheles tarsimaculatus*, Goeldi.

**Wyeomyia (Phoniomyia) fuscipes,** sp. n.

♀. *Head* with metallic violet scales dorsally ; sides silvery below ; a line of golden scales at the junction of the violet and silver areas. Eyes separated by nearly the width of two ommatidia. Clypeus dull, dark brown. Tori black, with a strong grey pollinosity. Proboscis dark, slender, longer than the long front femora. Palpi dark, about one-seventh as long as the proboscis. *Thorax* with shining blackish-brown integument ; scales of prothoracic lobes violet ; of mesonotum metallic bronzy ; of scutellum, pro-epimera and subspiracular area golden ; of remainder of pleurae silvery. Two or three small spiracular bristles. *Abdomen* blackish dorsally, pale golden laterally and beneath, the line of junction of the colours rather deeply incised, the black wedges situated at the apices of the tergites. Tergites 4–7 each with a small median basal whitish spot. *Legs* dark ; undersides of femora, tibiae, and first tarsal segments lighter ; no white markings on any of the tarsi. *Wings* with dark brown scales, the outstanding ones ligulate. Upper fork-cell nearly three times as long as its stem, its base nearer the base of the wing than is that of the lower fork-cell. Wing-length, 3 mm.

*Cotypes*, 2 ♀ (*Fiebrig*). No exact data.

This species is probably related to *W. trinidadensis*, Theo., differing in the entire absence of white on the tarsi and in other particulars. I think that *Phoniomyia* can be recognised as a good subgenus on the character of the proboscis, but whether its recent division by Bonne-Wepster & Bonne into *Phoniomyia*, *Dodecamyia* and *Dyarina* can be maintained seems open to serious question.

**Psorophora (Psorophora) ciliata,** Fab.

Some of the examples in the collection (all are females) seem to me to be indistinguishable from the North American species. They have the scales on the pre-scutellar space mostly flat and white, with a narrow area of golden ones in the middle. Some others may perhaps represent a distinct species (? *tibialis*, R.-D.) ; in these the pre-scutellar scales are all narrow and golden.

**Psorophora (Psorophora) pallescens,** sp. n.

*Head* clothed with pale buff-coloured flat scales. Proboscis and palpi mainly pale-scaled, some dark ones intermixed. Palpi of ♀ nearly one-half as long as the proboscis, of ♂ longer than the proboscis by nearly the length of the last two joints, which are upturned and swollen. Clypeus light brown. *Thorax* with the integument light brown, mesonotum largely blackish. In the centre of the mesonotum is a longitudinal row of narrow, curved, golden scales, bordered on each side by a row of broad, flat, pale buff scales ; external to this is a pair of narrow, bare, blackish stripes ; the remainder of the mesonotum covered with broad, pale buff scales, except for a pair of short and rather broad bare black stripes, widely separated, just in front of the scutellum, and a pair of small rounded spots of deep black scales in the middle. Postnotum light brown. Mesonotal bristles numerous, short, blackish. Pleurae with dense broad buff scales ; bristles pale ; pro-epimeral bristles very small and weak ; about three moderately long spiraculars ; numerous lower mesepimerals. *Abdomen* uniformly clothed with pale buff scales ; integument light. Male hypopygium practically as figured and described by Howard, Dyar and Knab for *Ps. ciliata*, Fab. Claspers with two sharp projecting points some little way before the tip. Tenth tergite with numerous short bristles ; tenth sternite with the tips cleft into three teeth. Lobes of ninth tergite each with about ten fine bristles. *Legs* pale ochreous ; tips of femora, and the whole of the tibiae and first two tarsal joints of the hind legs with long outstanding scales ; scales mostly pale, but with numerous dark ones intermixed. All joints of hind tarsi broadly white-ringed at the base.

Femora and tibiae of ♂ with long dense hair, much longer than the scales. *Wings* with mixed light and dark scales, the former preponderating on the costa and on most of the veins. Fork-cells about half as long again as their stems, their bases about level. Cross-veins closely approximated (actually in a line in one specimen). Wing-length, 6·5 mm.

*Cotypes*, 1 ♂, 4 ♀ (*Fiebrig*).

This is obviously the species described and figured by Arribalzaga as *Ps. ciliata*. Since, however, the present species does not appear to occur in North America, whence *Ps. ciliata* was described, it is likely that Arribalzaga's determination was incorrect. The thoracic ornamentation is very different in the two species, though the hypopygial structure shows that they are very closely allied. No specimens of *Ps. pallescens* have previously been received at the British Museum, nor apparently have any specimens been recorded apart from Arribalzaga's.

**Psorophora (Janthinosoma) fiebrigi,** sp. n.

*Head* with the integument mostly orange, becoming browner towards the front; clypeus blackish; scales orange; bristles blackish. Palpi purple-scaled; in ♀ about one-quarter as long as the proboscis; in ♂ slender, longer than the proboscis by nearly the length of the last two joints. Proboscis slender, about equalling the front femora, with appressed purplish scales. *Thorax* with the integument shining black. Mesonotum and pro-epimera with small flat bronzy scales, none lighter at sides. Scutellum similarly scaled. Bristles black. Pleurae (except pro-epimera and the bare area behind them) densely clothed with silvery-grey scales, without the least tinge of ochreous; bristles pale; two or three spiraculars; no lower mesepimeral. *Abdomen* purple-scaled dorsally, except for the first segment and the apical corners of the remaining segment, which are golden. Venter mostly golden, with narrow purple bands at the bases of the segments. Male claspers greatly expanded in the middle, and with a moderately long, slender, hooked tip; the expanded portion with a patch of short recurved bristles on the outer side. Stem of claspettes long and rather stout, suddenly bent almost at right angles a little beyond the middle, tip very slightly expanded; outer two filaments short and flattened, the outer one simple, the second distorted. *Legs* purple-scaled; hind femora golden at the base beneath; fourth hind tarsal segment white on the basal three-fifths to four-fifths, tip dark; last hind tarsal segment white beneath except at the tip, upper surface more or less darkened, more so in ♀ than in ♂. Tibiae and first two tarsal segments of hind legs with the scales raised, but not very long. *Wing* scales dark. Fork-cells with their bases level, about one-third longer than their stems. Wing-length 4 mm.

*Cotypes*, 5 ♂, 4 ♀ (*Fiebrig*).

Apparently most nearly allied to *Ps. posticata*, but smaller and with differently marked hind tarsi, rather shorter scales on hind legs, and differently formed claspettes.

**Psorophora (Janthinosoma) purpurascens,** sp. n.

♀. *Head* dark, with dark upright scales and scattered small silvery-grey scales. Palpi and proboscis with appressed purplish scales; palpi about one-fifth as long as the proboscis. Clypeus shining dark brown. *Thorax* with the integument black, somewhat shining. Mesonotum and scutellum with flat silvery-grey scales, darker, but not conspicuously so, in the centre of the mesonotum. Pro-epimera practically bare. Pleurae with dense flat silvery-grey scales. Mesonotal and most of pleural bristles blackish. Two or three small pale spiracular bristles; mesepimeral bristles also pale; about five lower mesepimerals present. *Abdomen* purplish dorsally,

each segment with a complete golden-yellow band ; the bands are apical at the sides of the segments, but in the middle are removed from the margin, which bears a small patch of purple-scales. Venter golden, the sternites narrowly purple at the base. *Legs* purple-scaled ; undersides of femora golden ; undersides of front and mid tarsi light brownish ; hind tarsi without any white ; hind tibiae stout but the scales scarcely raised, much shorter than the dense setae. *Wing* scales linear, all dark brown. Wing-length 4 mm.

*Type*, 1 ♀ (*Fiebrig*). No exact data.

Nearly allied to the North American *Ps. cyanescens*, Coq., but differing in the abdominal markings.

**Psorophora (Grabhamia) varinervis,** sp. n.

♀. *Head* with dark upright scales, and small golden-brown narrow curved scales. Eyes separated by the width of two ommatidia. Clypeus, tori, and first few flagellar segments ochreous-brown, remainder of antennae blackish. Proboscis ochreous-scaled, darker at the tip, slender, longer than front femora. Palpi ochreous-scaled, rather stout, scarcely one-fifth as long as the proboscis. *Thorax* with the integument dull chestnut-brown ; mesonotum with four darker stripes, the lateral pair abbreviated. Mesonotal scales minute, strongly curved, golden brown, those on and in front of the scutellum somewhat larger. Scales of prothoracic lobes, pro-epimera and post-spiracular area similar to those of the mesonotum ; those on mesepisternum and mesepimeron larger and paler. A posterior row of five pro-epimeral bristles ; three or four spiraculars ; about six post-spiraculars ; no lower mesepimeral. *Abdomen* with pale integument ; much denuded, but all the remaining scales are ochreous. *Legs* pale ; scales mainly ochreous, but numerous scattered dark ones are present on the femora, and the tips of the tarsal segments are dark ; scales at the bases of the last few tarsal segments almost white. There is no indication of a white ring in the middle of the first hind tarsal segment. Claws simple. *Wings* with the scales mainly ochreous, but with many scattered black ones ; costa entirely pale ; on the other hand, black scales preponderate at the tip of $R_1$, on $R_4+_5$, $M_2$, and the stem and branches of Cu ; at the base of $R_4+_5$ (third vein) the black scales are aggregated into a rather definite spot. Outstanding scales linear. Fork-cells nearly half as long again as their stems, base of upper one slightly nearer apex of wing. Cross-veins widely separated. Wing-length, 4 mm.

*Type*, 1 ♀ (*Fiebrig*). No exact data.

A very distinct species with no close ally. The coloration is rather suggestive of the Canadian *Aëdes* (*Ochlerotatus*) *spenceri*, but the presence of spiracular bristles and the simple claws show that the insect is a *Psorophora* of the subgenus *Grabhamia*. The small size of the mesonotal scales is noteworthy.

**Aëdes (Ochlerotatus) stigmaticus,** sp. n.

♀. *Head* yellow, clothed with golden-yellow mixed upright forked and narrow curved scales. Proboscis slender, longer than the front femora, black-scaled except at the base, where the scales are golden-yellow. Palpi scarcely a quarter as long as the proboscis, yellow-scaled, the tips black. Antennae with the tori and first flagellar segments yellow, the rest blackish. *Thorax* with the integument mainly yellow. On the front margin are four dark brown marks ; a pair of short stripes close together in the middle of the mesonotum, and a roundish spot on the upper anterior corner of each pro-epimeron. Above and just in front of each wing-root is a large oval black spot. Pleurae without dark markings, except for those on the pro-epimera.

Mesonotum with light brown bristles and rather scanty golden-yellow scales. Pleurae without scales; four pro-epimeral bristles; about six post-spiraculars; no lower mesepimeral. *Abdomen* yellowish, much denuded, the remaining scales golden-yellow. Seventh segment slender; eighth retracted; cerci apparently rather short. *Legs* with yellow integument; femora with golden-yellow scales, except at the tips, which are black; tibiae darker; tarsi blackish, without definite rings (but much rubbed). *Wings* with the scales mostly dark brown; costa and first vein yellow-scaled on the basal third only, the colour gradually shading to brown; scales narrow. Fork-cells about as long as their stems, base of upper slightly nearer the apex of the wing than that of lower. Wing-length, 5 mm.

*Cotypes*, 2 ♀; one from Asuncion, 1904 (*Vezènyi*), the other without data (*Fiebrig*).

The species is nearly allied to *A. fulvus* (Wied.), and *A. bimaculatus* (Coq.), differing from both in the shorter palpi and mainly dark-scaled wings, and from the former in the absence of a black band across the pleurae.

## B.—New and little-known Sabethines collected by Mr. G. E. Bodkin in British Guiana.

Included in collections which have been received from Mr. G. E. Bodkin during the past year are a number of interesting species of mosquitos, notes on which are appended. Many species of *Wyeomyia* were sent, and in the course of determining these I noticed some interesting peculiarities in the middle tarsi of the males, which seem to give much needed assistance in the discrimination of nearly allied species. These characters have not heretofore been described accurately, and I have therefore figured some of them. The types of the two new species, and most of the other specimens referred to, have been presented to the British Museum through the Imperial Bureau of Entomology.

**Goeldia longipes,** Fab.

2 ♀, Issororo, ix.1921; attacking man; diurnal.

These are the first specimens of this rare and beautiful species which have been received at the British Museum.

**Sabethoides imperfectus,** B.-W. & B.

1 ♀, Ulauna, Kariabo, Aruka River, ix.1921; attacking man; diurnal.

A ready means of distinction from *S. nitidus* is found in the upper mesepimeral bristles. In *S. nitidus* these are of the ordinary length, but in the specimen of *S. imperfectus* before me they are extremely long, curving over the base of the postnotum and almost meeting in the middle line.

**Wyeomyia splendida,** B.-W. & B.

1 ♂, 1 ♀, Rockstone, 29.vii.1921, bred from larvae inhabiting Bromelias; 1 ♂, Aruka River, 16.ix.21, bred from larva in Bromelia; 1 ♀, Issororo, ix.21, bred from larva in *Heliconia*.

The fourth mid-tarsal segment of the ♂ (fig. 1, *s*) has a single long, slender spine at its tip; the fifth segment is about two and a half times as long as its average breadth, with a large rounded prominence in the middle beneath, the prominence

bearing a dense tuft of short scales (appearing like spines in the dry specimen). Claws both strongly chitinised and equal in length, but one much broader than the other.

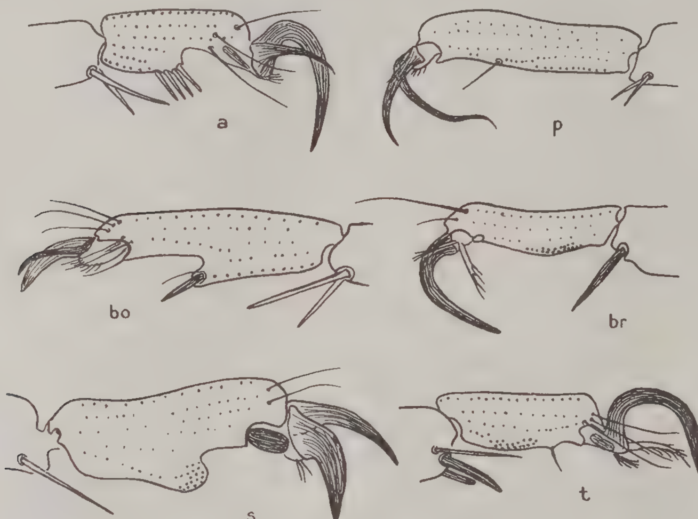


Fig. 1. Last tarsal segment of mid legs of ♂♂ of *Wyeomyia*; scales omitted, their bases represented by dots: (*a*) *W. aphobema*, Dyar; (*bo*) *W. bodkini*, sp. n.; (*br*) *W. bromeliarum*, D. & K.; (*p*) *W. pseudopecten*, D. & K.; (*s*) *W. splendida*, B.-W. & B.; (*t*) *W. telestica*, D. & K.; all × 200.

**Wyeomyia pseudopecten,** D. & K.

A series from Issororo, bred from larvae in Heliconias.

The last segment of the mid tarsi of the ♂ (fig. 1, *p*) is simple, nearly cylindrical, about four times as long as broad with moderately dense scales on the basal half of the underside, and a fine bristle rather beyond the middle. Its claws are both strongly chitinised and rather large, one longer and much more curved than the other, with a long fine sinuous point.

**Wyeomyia bromeliarum,** D. & K.

A long series from Georgetown, reared from larvae in bamboo stumps, also 1 ♀ labelled as having been reared from bromelias; conceivably there may have been an error in labelling this specimen, the species being reputed to be restricted to bamboos.

The fourth mid-tarsal segment of the ♂ (fig. 1, *br*) bears a single strong spine at its tip. The fifth segment is slightly enlarged beneath and bears a dense scale-tuft just before the middle. One claw is large, sickle-shaped and strongly chitinised; the other is apparently represented by a much shorter, thin, pale and slightly hairy structure resembling an empodium.

**Wyeomyia telestica,** D. & K.

A series from Issororo, bred from larvae in leaf-bases of pineapple plants and bromelias.

The fourth mid-tarsal segment of the ♂ (fig. 1, *t*) has one thin spine and two shorter thick ones at its tip. The fifth segment resembles that of *W. bromeliarum*, but is

shorter and the chitinised claw is curved more into a semicircle. The ♂ claspers carry a long and excessively fine hair at the tip of one of the lobes, which is omitted from Howard, Dyar and Knab's figure.

**Wyeomyia bodkini,** sp. n.

♂. *Head* clothed with blackish scales, which have a rather distinct blue reflection when viewed from in front ; white scales low down at the sides, but no trace of a white eye-margin. Eyes very narrowly separated, but distinctly so above the antennae, though at the vertex they are practically touching, the line between them greyish, without scales. Tori and clypeus bare, blackish, with a rather pronounced pale grey dusting. Tips of flagellar segments narrowly white ; the last segment a little longer than the others. Proboscis black, of the same length as the abdomen, slightly but distinctly swollen at the tip. Palpi thin, black, about as long as the clypeus. *Thorax* : prothoracic lobes rather large, not very widely separated, clothed mainly with brilliant blue scales, passing to coppery below, and with a few white scales on the lower margin. Pro-epimera densely clothed with silvery scales. Mesonotum black, densely covered with flat black scales, larger posteriorly.

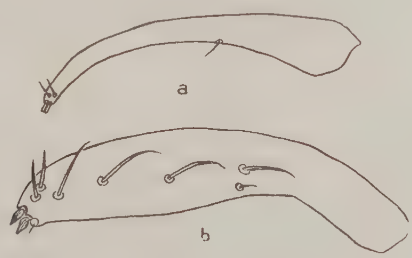


Fig. 2. Male claspers of *Wyeomyia* : (*a*) *W. aphobema*, Dyar ; (*b*) *W. bodkini*, sp. n.

Postnotum dark brown, with four long dark bristles, no scales. Pleurae densely clothed with silvery scales. Two spiracular bristles ; no pro-epimerals. *Abdomen* black above, shining white at the sides and beneath, the colours separated in a straight line. *Hypopygium* : lobes of ninth tergite each with five stout and rather short bristles. Side-pieces with a row of about eight strong bristles in the middle of the inner face, and with a slight subapical lobe bearing one rather long bristle and one or two fine hairs. Clasper simple, slightly swollen on its apical two-thirds, with several long, curved hairs and two short terminal claws. Tenth sternites with a vertical row of four terminal points. *Legs* blue-black. Front tarsi with a white line beneath on the last three segments. Mid tarsi with the last four segments almost entirely white, with a very narrow dark line beneath, the second segment more extensively dark beneath on the basal third. Hind tarsi entirely dark. Last segment of mid tarsi (fig. 1, *bo*) over three times as long as its greatest breadth, with a swelling in the middle of the underside bearing one small slender spine, its claws both rather small, slightly curved, nearly equal in length, but one much stouter than the other. Hind tibiae about one-fourth shorter than the middle ones, with about six longish bristles on the underside, none dorsally. *Wings* with the scales all dark, the outstanding ones mostly rather short, narrowly ovate. Upper fork-cell about twice as long as its stem. Wing-length, 2·8 mm.

♀. Coloration exactly as in the ♂. Antennal hair-whorls somewhat shorter. Middle claws both alike. Wing-scales rather longer and denser.

*Cotypes*, 2 ♂, 1 ♀, Issororo, N.W. district, ix.1921, bred from larvae inhabiting bases of pineapple plant ; also 2 ♀, same locality and date, bred from larva inhabiting bromelias.

The only described species which seems to be nearly allied to this is *W. aphobema*, Dyar, in which the male claspers are much more slender, and which probably differs also in the structure of its middle feet.

**Wyeomyia aphobema,** Dyar.

2 ♂, Issororo, ix.1921, bred from larvae inhabiting bases of leaves of pineapple plant, associated with *W. bodkini*, sp. n., and *W. telestica*, D. & K.

The coloration of these examples is almost precisely as in *W. bodkini*, which I at first took to be merely a form of *W. aphobema* ; but the male hypopygium differs distinctly and agrees fairly well with Dyar's description and subsequent figure. According to Dyar's description the mid-tarsi are white *beneath*, but this is perhaps an error, since in the specimens before me the white on the mid tarsi extends almost all round, but leaves a narrow *dark* line beneath, as in *W. bodkini*. The male claspers apparently bear only three fine hairs and only two minute terminal spines.

The last mid tarsal segment (fig. 1, *a*) is only a little over twice as long as its greatest breadth, and bears four small spines in the middle beneath ; its claws are very unequal, the larger one strongly curved, sickle-shaped.

**Wyeomyia flavifacies,** sp. n.

♀. *Head* dark, the scales with a purplish reflection ; a narrow silvery margin to the eyes, enlarging above into a small bluish-silvery vertical spot. Eyes separated by a narrow unscaled line. Clypeus large, pale yellow, shining, bare. Proboscis slender, a little longer than the abdomen, tip not enlarged, uniformly dark-scaled. Palpi slender, dark, about as long as the clypeus. Tori yellowish, covered with a distinct grey dusting. Flagellar joints dark ; hair-whorls very long. *Thorax* with the integument ochreous. Prothoracic lobes with violet scales. Pro-epimeral scales golden. Mesonotum and scutellum with broad dark brown scales. Pleurae white-scaled. Two spiracular bristles ; no pro-epimeral. Postnotum with about eight black bristles. *Abdomen* blackish above, golden below, the colours separated in a straight line. *Legs* blackish ; front femora with a whitish line antero-ventrally, extending the whole length ; knees narrowly pale ; front and mid tarsi entirely dark, also the first two segments of the hind tarsi (last three missing). *Wings* with dark scales, the outstanding ones linear. Upper fork-cell more than twice as long as its stem. Wing-length, 3 mm.

*Type* ♀ (unique), Aruka River, 16.ix.1921 ; bred from larvae inhabiting bromelias.

I can find no described species which resembles this at all closely.

## C.—A New *Stegomyia* from Nyasaland.

**Aëdes (Stegomyia) woodi,** sp. n.

♀. Closely allied to *A. simpsoni*, Theo., differing only in mesonotal ornamentation, as follows :—The white patch on the anterior margin is smaller and composed of narrower scales. The two main white patches are much smaller, rather narrowly crescent-shaped, almost as in *A. argenteus*. The two admedian golden lines are more evident than is usual in *A. simpsoni*, and run distinctly the whole length of the mesonotum. The pair of shorter lines in front of the scutellum are golden instead of white, and composed of very narrow scales. The scutellum has white scales on the median lobe, black scales on the lateral lobes.

Nyasaland : Cholo, 20.iv. 1916 (*R. C. Wood*).

*Type* ♀ presented to the British Museum by the Imperial Bureau of Entomology.

In its thoracic ornamentation this species shows a closer approach to *A. argenteus* than does any other known African species. From *A. apicoargentea*, the only other African species with similar scutellar scaling, *A. woodi* differs in leg-markings and in other respects.

## D.—On the Grouping of the Ethiopian Species of *Culex*, with Notes on Certain Species.

Since the publication of my paper on the African species of *Culex*, much work has been done on the genus ; many new species have been described, and a considerable number have been reared from larvae. More recently a fresh study of the adults has enabled me to discover additional characters which seem to be valuable for the separation of the species into groups, and for the discrimination of some closely-allied forms. We are therefore now in a much better position for arriving at a natural classification of the genus.

As I would now define the genus, it should include *Culiciomyia*, *Eumelanomyia*, *Protomelanoconion* and *Micraëdes*, but, on the other hand, *Culex tigripes* should be transferred to the genus *Lutzia*, which it will be convenient to recognise as distinct from *Culex*. For the classification of the genus in a natural manner, the most reliable characters seem to be those of the male hypopygium, and as will be mentioned below, there are one or two interesting cases of the correlation between these structures and points in the larval morphology. However, to base a classification entirely or even mainly on the male genital characters is very inconvenient, and I have therefore searched for others which will be applicable to both sexes. Although much remains to be done, it may be useful now to mention the results so far obtained.

A very important distinction seems to be in the presence or absence, and in a few cases the duplication, of the bristle on the lower part of the mesepimeron. I have already used this character for the separation of *Lutzia* from *Culex*, the former genus having at least six lower mesepimeral bristles, while the latter has 0–4, but generally one. It now appears that a further use can be made of these bristles in dividing up the genus *Culex*.

Another point of importance is in the distribution of scales on the pleurae. Too little attention has been given to this by previous writers (myself included). It would seem from my recent studies that the presence or absence of scales on particular areas of the pleurae is constant for each species. The scales are of course liable to denudation, and only perfect specimens can be discussed in this respect, but the pleural scales are better protected and therefore less easily denuded than those of the mesonotum. The two areas which seem to be of the most importance in this connection are the mesepimeron, and the area immediately behind the prothoracic spiracle. The latter area (post-spiracular) is never completely covered with scales in *Culex*, but in some species there is a patch of flat white scales on its anterior margin, adjoining the spiracle. The size of the patch of scales on the mesepimeron varies with the species, and in some it is entirely absent.

The palpi of the females often provide useful specific distinctions, in their length (relatively to the clypeus or to the proboscis) and in the proportionate lengths and breadths of their segments. Sometimes the distinctions in this respect are quite marked even between closely allied species.

The Ethiopian species of *Culex* may be divided into four main groups, to which must be added, perhaps as distinct subgenera, the four other minor groups, *Protomelanoconion*, *Micraëdes*, *Culiciomyia* and *Eumelanomyia*, all of which show affinity in one way or another with the fourth of the main groups. These groups may be briefly considered.

Group I. The *bitaeniorhynchus* group. Lower mesepimeral bristle absent; proboscis with a distinct and not very broad pale ring in the middle; tarsi with narrow pale rings embracing both ends of the segments. Male aedoeagus generally of complicated structure, usually with one or more pairs of dorsally-directed hooks.

This is evidently a natural group, and includes all the ringed-legged species except *C. duttoni* and *C. ventrilloni*. It divides into two series, as follows :—

1. The *bitaeniorhynchus* series (*C. quasigelidus*, *C. consimilis*, *C. annulioris*, *C. giganteus*, and *C. bitaeniorhynchus*, with its variety *aurantapex*). Pale scales of abdominal tergites to a large extent apical in position; mesonotum tending to have the front two-thirds pale-scaled. Lobe of side-piece of male hypopygium without a well-marked leaf. Larva with the scales on the comb of the eighth segment few and large; siphon long. Should it be considered desirable to treat this series as a separate subgenus, the name *Aporoculex* is available, having been proposed for *C. quasigelidus*.

2. The *sitiens* series (*C. sitiens*, *C. thalassius*, *C. tritaeniorhynchus*). Pale scales of abdominal tergites mainly basal; mesonotum with the pale scales fewer and more scattered. Lobe of side-piece with a well-marked leaf. Larva with the scales on the comb of the eighth segment numerous and small.

Group II. The *duttoni* group. Three (in some specimens two or four) lower mesepimeral bristles present. Aedoeagus of simple structure. Lobe of side-piece with a well-marked leaf. Siphon of larva rather short and swollen towards the middle.

This includes only three species, *C. duttoni*, Theo., *C. watti*, Edw., and *C. pruina*, Theo. Though they are very dissimilar in coloration, the points of similarity in the mesepimeral bristles, in the male hypopygium and in the larval siphon clearly indicate that they are related. *C. duttoni* is obviously not closely connected with the other ringed-legged species; apart from the more important differences mentioned above, the colouring of the proboscis is quite unlike that of any member of the *bitaeniorhynchus* group.

Two quite different larvae have been attributed to *C. pruina*, but in view of the resemblances now discovered between the adults of this species and of *C. duttoni*, it will be safe to assume that Ingram and Macfie were correct in their determination, while Graham was in error.

This group is not very clearly marked off from the next, *C. guiarti* and *C. grahami* being in some respects intermediate. The last-named species has two lower mesepimeral bristles. The Palaearctic *C. laticinctus*, Edw., shows some affinity with this group, both as regards adult and larva.

Group III. The *pipiens* group. One lower mesepimeral bristle (two in *C. grahami*). Proboscis and tarsi without pale rings (except in *C. ventrilloni*). Abdominal tergites with basal pale markings (bands or more or less distinct lateral spots). Male aedoeagus nearly always of complicated structure (rather simple in *C. guiarti* and *C. grahami*, but then, as in most of the other species, with a pair of processes from the lower bridge), but without dorsally-directed hooks. Lobe of side-piece with a distinct leaf. Larval siphon generally elongate and slender; comb of eighth segment with numerous small scales.

This group includes the majority of the Ethiopian species. It may be divided into the following two series :—

1. The *pipiens* series. Male palpi with a white line on the lower surface of the last two segments. Abdominal tergites with complete basal pale bands (except

in varieties of *C. pipiens*, *C. fatigans* and *C. univittatus*). The following Ethiopian species belong to this series :—

| | |
|---|---|
| *C. ventrilloni*, Edw. | *C. fatigans*, W. |
| *C. tipuliformis*, Theo. | *C. pallidocephalus*, Theo. |
| *C. univittatus*, Theo. (with var. *neavei*, Theo.) | *C. mirificus*, Edw. |
| *C. simpsoni*, Theo. | *C. andersoni*, Edw. |
| *C. pipiens*, L. | *C. trifilatus*, Edw. |

Of these species, *C. ventrilloni* is well distinguished by its basally-ringed tarsal segments, *C. tipuliformis* by its lined femora and tibiae, and *C. univittatus* and *C. simpsoni* by the presence of post-spiracular scales. *C. neavei*, Theo., is structurally identical with *C. univittatus*, of which it should doubtless be regarded as a variety. The presence of post-spiracular scales will help to distinguish it from the members of the next series.

2. The *decens* series. Last two segments of male palpi dark beneath (traces of a white line in *C. laurenti* only). Abdominal tergites with basal lateral pale spots (bands complete only in the typical form of *C. decens*).

This series is exclusively Ethiopian, and comprises the following species :—

| | |
|---|---|
| *C. argenteopunctatus*, Ventrillon. | *C. perfuscus*. Edw. |
| *C. laurenti*, Newst. | *C. trifoliatus*, Edw. |
| *C. decens*, Theo. (with var. *invidiosus*, Theo.). | *C. scotti*, Theo. |
| *C. ornatothoracis*, Theo. | *C. grahami*, Theo. |
| *C. perfidiosus*, Edw. | *C. guiarti*, Blanch. |
| | *C. ingrami*, Edw. |

*C. argenteopunctatus* differs from the other species not only in the conspicuous silvery spots on the thorax, but also in the possession of a conspicuous patch of post-spiracular scales. It seems, however, to be quite in place in this series. The last three species mentioned diverge in having the male aedoeagus of rather simple structure, and in some specimens at least, in the possession of two lower mesepimeral bristles. The larval siphon, however, is extremely elongate, and they seem better placed here than in the *duttoni* group.

GROUP IV. The *rima* group. One lower mesepimeral bristle (none in *rubinotus*). Proboscis and tarsi without pale rings. Abdominal tergites with the pale markings apical (sometimes absent). Aedoeagus of simple structure, often tuberculate, no processes from lower bridge. Lobe of side-piece with a distinct leaf. Eighth sternite of ♂ deeply emarginate, allowing the hypopygium to project downwards. Larva as in Group III.

This group corresponds more or less to Dyar's subgenus *Neoculex*. There are only five Ethiopian species. *C. pulchrithorax*, Edw., is extremely distinct on account of the five white lines on the black thorax, suggesting a *Stegomyia* or *Finlaya*. The other four species (*C. rima*, Theo., *C. rubinotus*, Theo., *C. salisburiensis*, Theo., and *C. kingianus*, sp. n.) are at first sight very similar, but nevertheless show well-marked distinctions. They are dealt with in more detail below.

**Culex ornatothoracis,** Theo.

I have previously given this as a synonym of *C. decens* var. *invidiosus*, on account of the fact that the hypopygia are nearly, if not quite, identical. There is, however, a very noticeable difference in thoracic ornamentation, and apart from this there seems also to be a difference in the structure of the female palpi ; those of *C. decens* are considerably shorter, the second (last) segment less than twice as long as the first, while in *C. ornatothoracis* the second segment is quite three times as long as the first. The species are therefore probably distinct.

**Culex trifoliatus,** Edw.

This species can be distinguished from most of its allies by having the tip of the hind femora more broadly dark, the apical sixth being dark all round.

A good series has been received from the southern Sudan (*H. H. King*; various localities) and I have also seen the species from the Congo.

**Culex rima,** Theo.

This species may be very readily distinguished by the pleural markings. The ground-colour of the pleurae is pale; a broad blackish stripe adjoins the margin of the mesonotum, and there is another but much narrower dark stripe some way below and parallel with the upper one. These markings vary somewhat in intensity, and in immature specimens are faint, but are always traceable. Apart from this, the female may be known by its palpi, which are very much longer than in the other three species of the group, and about three times as long as the clypeus, the last segment being longer than the basal segments together.


Fig. 3. Ethiopian species of *Culex*; upper row, anal and genital parts, from above; lower row, clasper and apex of side-piece, from the side: (*s*) *C. salisburiensis*, Theo.; (*r*) *C. rima*, Theo., specimen from the Sudan; (*c*) *C. rima*, specimen from Old Calabar; (*k*) *C. kingianus*, sp. n.; all × 180.

In the hypopygium, the most noteworthy points are the membranous subapical expansion of the tenth sternites, and the long slender clasper. The lobe of the side-piece bears three long flat plates (in place of the usual rods), three short and more or less flattened bristles, and a large round-tipped leaf. The three plates vary rather considerably in shape in specimens from different localities.

There are no mesepimeral scales, and the lower mesepimeral bristle is distinct.

**Culex kingianus,** sp. n.

♂. *Head* with narrow white scales dorsally, flat white ones at the sides, extending upwards as a narrow border to the eyes almost to the vertex. Upright scales dark

brown. Bristles black. Eyes touching. Tori and clypeus dark brown, bare, somewhat shining. Proboscis normal, with dark brown scales. Palpi with dark brown scales, only exceeding the proboscis by about half the length of the last segment. Long segment without hairs; last two segments rather conspicuously hairy, gradually tapering, not very distinctly separated, penultimate about half as long again as the terminal. *Thorax* dark brown, integument somewhat shining, without dark markings either on mesonotum or pleurae. Mesonotal bristles light brown; scales dark brown, moderately large. A narrow line of inconspicuous pale flat scales extending vertically across the sternopleura. Mesepimeron without scales; a distinct lower mesepimeral bristle. *Abdomen* rather long and narrow, black-scaled dorsally, with faint traces of apical lateral segmental pale spots; venter rather dark brown, apical margins of sternites pale. Eighth sternite deeply emarginate apically, as in other species of this group. Hypopygium: lobe of side-piece with three long, slightly sinuous rods with hooked tips; five or six shorter and more or less flattened bristles; a broad but sharply pointed leaf, and the usual apically-placed bristle. Clasper moderately long, gently curved. Tenth sternites with rather long and dense terminal spines; no basal arm; no subapical membranous expansion. Mesosomal lobes with their inner faces tubercular; tips turned outwards. *Legs* dark brown; hind tibiae without a pale spot at the tip; hind femora white beneath and on the outer side to the tip. *Wings* with the outstanding scales somewhat clavate; fork-cells rather longer than their stems, base of upper slightly nearer the wing base; cross-veins separated by quite twice the length of the posterior. Wing-length 3–3·5 mm.

♀. Resembles the ♂. Palpi short, terminal segment about as long as the clypeus, somewhat swollen, hairy at the tip.

SUDAN: River Menzi, 4.iii.1911, 3 ♂ (including type); Bundle to Hierallah, 20.iii.1911, 1 ♂ (*H. H. King*). Presented to the British Museum by Mr. F. V. Theobald. S. NIGERIA: Lagos, xii.1901, 1 ♀ (*Dr. H. Strachan*); Degema, x-xii.1910, 1 ♀ (*Dr. J. W. Collett*). ASHANTI: Obuasi, ix.1907, 1 ♀ (*Dr. W. M. Graham*).

Distinguishable from *C. rubinotus* by the larger mesonotal scales, presence of lower mesepimeral bristle, and shorter ♂ palpi; from *C. salisburiensis* by the absence of mesepimeral scales and shorter ♂ palpi; and from *C. rima* by the unmarked pleural integument; also from all these by the structure of the hypopygium.

**Culex rubinotus,** Theo.

In this species the mesonotal scales are very small, much smaller than in its three allies, and in some conditions of illumination appear quite black. The mesonotal integument is reddish, but not always of such a bright brick-red as in the type. The pleural integument is lighter than that of the mesonotum, without dark markings. The mesepimeron is remarkable in having no bristle on its lower part; nor has it any scales. Palpi of ♂ longer than the proboscis by the last segment and half the penultimate; last two segments about equal in length. Palpi of ♀ with the last segment rather short and swollen, though less so than in *C. salisburiensis*. Hypopygium: lobe of side-piece with two (or three ?) long rods, two shorter curved appendages, and a moderately broad but pointed leaf. Clasper rather short and broad. Basal parts almost as in *C. kingianus*, but the lateral angles of the mesosomal lobes are more prominent, and their tips are not recurved.

At present only the type ♀ of this species has been recorded, but additional material has been received at the British Museum as follows:—UGANDA: Kampala Swamp, xi.1909, 1 ♂, 1 ♀ (*Major A. D. Fraser*). SUDAN: Meridi, 12.iii.1911, 1 ♀, and Idris, 16.iii.1911, 1 ♀ (*H. H. King*).

**Culex salisburiensis,** Theo.

As in the case of *C. rima*, the abdominal markings of this species are variable, the tergites sometimes having complete apical white bands, sometimes lateral spots only. The species may be known from its allies by the possession of a large patch of scales on the basal half of the mesepimeron. The lower mesepimeral bristle is present. Hypopygium: side-piece much as in *C. rima*, but clasper somewhat bent. Mesosomal lobes flat, pale, and devoid of tubercles. Tenth sternites with few spines, the inner ones bristly, the outer ones stout and blunt-tipped.

**Culex horridus,** nom. n.

*Protomelanoconion fusca*, Theobald, Mon. Cul. v, p. 463 (1910).

This change of name is necessary since the specific name *fuscus* is preoccupied in *Culex* by *Trichorhynchus fuscus*, Theo. The species is extremely close to the Oriental *C. brevipalpis*, Giles, but differs rather noticeably in the structure of the aedoeagus. This organ is of simple structure, with the lobes tubercular, as in several species of the *rima* group. The clasper is simple. It can hardly be included in the *rima* group since the abdominal tergites have basal instead of apical pale spots; moreover the species is well distinguished from all other Ethiopian species except *C. inconspicuosus* by the unusually long and stout bristles which occur over nearly the whole of the mesonotum. This character (which has suggested the specific name), together with the absence of flat scales on the top of the head, may perhaps be used to define the subgenus, which should probably include some species in which the palpi are alike in the two sexes; among others, perhaps, the type-species of *Micraëdes*.

**Culex inconspicuosus,** Theo.

*Aëdes inconspicuosus*, Theobald, Entom., xli, p. 109 (1908).

Although very similar in general appearance to *C. horridus*, this species may be readily distinguished from all other African *Culex* by the entire replacement of the narrow scales of the head by flat ones. The abdomen is without pale markings. As in *C. horridus* there is a single well-marked lower mesepimeral bristle. The male aedoeagus has the simple type of structure, but the clasper is peculiar in having a large projecting dorsal process. The Oriental *C. malayi* is closely allied but quite distinct.

I have referred this species to the subgenus *Micraëdes* on account of the very short male palpi. It differs, however, from the type of the subgenus (*M. bisulcatus*, Coq.) in its flat-scaled head and forked claspers, both these characters being of more importance than those of the palpi. If, therefore, it is desired to place it in a separate subgenus, a new name will probably have to be proposed, unless the insufficiently known *Aedinus*, Lutz, should prove to be applicable.

**Culex albiventris,** nom. nov.

*Eumelanomyia inconspicuosa*, Theobald, Mon. Cul. v, p. 240 (1910).

Theobald's specific name being preoccupied by his *Aëdes inconspicuosus* (both species really belonging to *Culex*) the above change of name is necessary.

There are two varieties of this species: in one the mesonotal scales are all blackish, in the other there are large whitish patches on the shoulders. The two are identical in all other respects. The species may be easily known by the black dorsum and pure white venter; as well as by the head scaling and the palpal structure of both sexes. The hypopygial structure is as in *Culiciomyia*, but the absence of a comb of scales on the male palpi excludes the species from that subgenus.

**Culex (Culiciomyia) nebulosus,** Theo.

?*Culex invenustus*, Theo.
*C. pseudocinereus*, Theo.
?*C. nigrochaetae*, Theo., ♀.
*Pectinopalpus fuscus*, Theo.

A more intensive study of the African *Culiciomyia* has revealed the fact that there exist three quite distinct types of male hypopygium, which I now consider should be regarded as distinct species, though the distinctions are otherwise very feebly marked. I have, however, examined a number of hypopygia of each form, and have seen no suggestion of intergradation. All three forms are widely distributed.

*C. nebulosus* was described from females only, and it is therefore largely a matter of conjecture to which form the name should be applied. I propose to fix it on the one which seems to be the commonest.

Hypopygium: side-pieces with a rather small ventro-lateral patch of hair. Lobe moderately large, with three spines and two leaves, but without a patch of fine curved hairs; the spines are moderately stout, the basal one straight and shorter than the other two, which have curled tips, middle spine the stoutest of the three; the leaves are very unequal in breadth, the apical one being very much broader than the other, and nearly as broad as long. Clasper bent in the middle, with a membranous expansion all round the outside of the bend, and with a conspicuous subapical spiny crest. Lobes of mesosome each with an apical fringe-like process which is moderately stout and about as long as the swollen basal part; at the base of the finger on the inner side is a well-marked tooth; the pair of fingers rather widely separated. Tenth sternites short and stout, without basal arm; apical spines numerous, those on the outer side stout and blunt.

Vein-scales towards tip of wing slightly clavate. Pleurae with the integument uniformly dark, heavily dusted with grey. Coxae with patches of white or whitish scales.

I have seen males of this species from the following localities:—GOLD COAST: Obuasi (*Graham*); Accra (*Connal*). SIERRA LEONE: Daru (*Murphy*); Freetown (*Bacot, Gratton*). S. NIGERIA: Lagos (*Strachan*). BELGIAN CONGO: Kabinda (*Schwetz*); Coquilhatville (*Massey*). UGANDA: Busu (*Fraser*). SUDAN: Kajo Kaji (*King*). RHODESIA: Salisbury (*Marshall*). TANGANYIKA TERR.: Dar-es-Salaam (*Pomeroy*).

**Culex (Culiciomyia) cinereus,** Theo.

?*Culex impudicus*, Ficalbi.
?*C. mundulus*, Grünberg.
*Culiciomyia freetownensis*, Theo.
*C. uniformis*, Theo.

This species is distinctly larger on the average than *C. nebulosus*, being about the size of *C. pipiens*. I can find no constant external distinctions between the two, but of *C. cinereus* there are two rather well-marked varieties: (*a*) type form: mesepimeron with a large patch of white scales almost covering its basal half, abdominal tergites with large greyish-white apical lateral patches, upper fork-cell in ♀ less than three times as long as its stem; (*b*) var. *uniformis*: mesepimeron with only a few pale scales near its base, abdominal tergites with few or no pale scales apically, upper fork-cell in ♀ fully three times as long as its stem. These two varieties have identica hypopygia, and differ from *C. nebulosus* as follows:—side-pieces somewhat more swollen and with a larger ventro-lateral hair-patch. Lobe larger, the spines rather stouter and more widely separated; a patch of about 20 soft curved hairs on the apical part of the lobe. Mesosome constructed as in *C. nebulosus*, but rather more strongly chitinised.

Unless the Mediterranean *C. impudicus* should prove to be the same, this species appears to be confined to West Africa. I have seen males from the following localities only: SIERRA LEONE: Freetown (*Austen*). GOLD COAST: Bibianaha (*Spurrell*); Obuasi (*Graham*); Koforidua (*Corson*).

**Culex (Culiciomyia) cinerellus,** sp. n.

Differs from *C. nebulosus*, Theo., as follows:—Average size smaller (and therefore much smaller than *C. cinereus*). Pleurae slightly shining, not distinctly dusted with grey, without scales; darker towards mesonotum and sternum, the intermediate part slightly but distinctly paler. Wing scales linear. Coxae apparently without scales. Hypopygium: side-piece without ventro-lateral hair-patch. Lobe smaller; spines longer in proportion and more slender, placed close together, with one long and two short associated bristles; leaves both quite short and narrow. Clasper less bent, with a less distinct membranous expansion. Finger-like processes of mesosome placed close together, very long and slender, about twice as long as the basal part, without a distinct tooth at the base.

UGANDA: Kasala, ix.1910, reared from larvae, type ♂ and 4 ♀ (*Major A. D. Fraser*). SUDAN: Kapei, 1.iv.1911, 1 ♂ (*H. H. King*). S. NIGERIA: Lagos, 15.viii and 21.xi.1910, 2 ♂, 1 ♀ (*Dr. W. M. Graham*).

## E.—ON A COLLECTION MADE BY DR. H. COGILL AT KARWAR, N. KANARA, INDIA.

In February 1922 a collection of about 350 specimens of mosquitos, together with some other insects, was presented to the British Museum by Dr. H. Cogill, the material having been collected by him while at Karwar, N. Kanara, India, in the years 1901–5. The collection is of historical interest, since it contains a number of examples of *Anopheles culiciformis*, Cogill, which, until its recent redescription by Christophers and Khazan Chand (Ind. Jl. Med. Res., iii, No. 4, 1916), was not known to exist in any public collection, and the original types were supposed to have been lost. Below are given notes on the more interesting species in the collection, including descriptions of two which are apparently new to science.

**Anopheles (Anopheles) culiciformis,** Cogill.

The collection contains several examples of each sex of this species, besides a few mounted larvae. Both adults and larvae agree almost entirely with Christophers' and Khazan Chand's detailed description, the only difference being that the female palpi are decidedly less shaggy, the scales being rather closely applied. The palpi in both sexes, however, are decidedly stouter than those of *A. aitkeni*. I cannot detect palmate hairs on the thorax of the larvae, but these were described and figured by Cogill and are no doubt present in perfect specimens. Since no type specimen was selected by Cogill, the examples in this collection may be regarded as cotypes.

**Anopheles (Myzomyia) subpictus** var. **vagus,** Dön.

This is represented in the collection by a number of examples, being about as numerous as the type form. In one example the dark wing-markings are greatly reduced, being almost confined to three very small patches on the costa and first vein. This specimen is interesting as lending support to the view, which has been expressed by Swellengrebel and adopted by the present writer, that Theobald's *A. immaculatus* is merely an albinoid aberration of *A. subpictus* var. *vagus*.

**Anopheles (Myzomyia) minimus,** Theo.

This is the most abundant *Anopheles* in the collection, and, as indicated by the labels attached, is the species which was recorded by Cogill as *A. fluviatilis*. All the specimens are of the typical form, the proboscis being dark both above and below;

the outer half of the sixth vein all dark ; no pale fringe-spot at the sixth vein. The amount of dark scaling on the third vein is variable ; in the majority of specimens only the middle third of the vein is pale.

I may mention here what seems to me to be the best distinguishing character of the larva of this species : the chitinised plates on the anterior margins of the abdominal segments are all extremely large, so much larger than in almost all other *Anopheles* that the species may be recognised at a glance under a hand lens. Swellengrebel has described and figured these structures in *A. minimus* var. *aconitus*, but does not emphasise their importance or make use of them in his key. The plates are almost or quite the same in the African *A. funestus*, this being the only other species among those which I have examined, which shows them of anything like the same size as in *A. minimus*. According to James and Liston's figures the plates are quite small in *A. culicifacies*, but large in *A. listoni*, though in the figure of this latter species they appear much narrower than they are in *A. minimus* and *A. funestus*. If Christophers is correct in regarding *A. listoni* as identical with *A. funestus*, this figure is probably inaccurate. *A. funestus* and *A. minimus* are very closely allied species, differing mainly in the markings of the female palps, the two outer pale bands being broader in the latter species. The two occupy to a large extent separate geographical areas, and might perhaps be regarded as representative forms of the same species.

**Uranotaenia alboannulata,** Theo.

The collection contains 1 ♂, 2 ♀. The species was previously known only from Theobalds' type ♀. I have formerly considered it identical with the Malayan *U. trilineata*, Leic., but it differs in the absence of a median white ring on the first hind tarsal segment, and perhaps in some other small particulars. The legs of the ♂ exhibit no peculiarities of structure.

**Uranotaenia campestris,** Leic.

The collection contains several specimens, representing both sexes ; they agree well with Leicester's cotypes in the British Museum, except that the scales towards the base of the first vein are less conspicuously white, and in some specimens hardly paler than the remaining wing-scales. The first front tarsal segment of the ♂ of this species is scarcely longer than the second, that of the ♀ being about one-half longer. The species has previously been recorded only from the Malay Peninsula.

**Uranotaenia recondita,** sp. n.

*Head* clothed with rather light brown flat scales and dark brown upright scales. Proboscis dark, moderately slender, slightly longer than the abdomen, scarcely swollen at the tip. Palpi longish, exceeding the clypeus by nearly twice its length. Antennae of ♀ longer than the proboscis by the length of the last two segments, pubescence rather long and evenly distributed along the segments ; of ♂ scarcely as long as the proboscis. *Thorax* dark brown ; integument of pleurae lighter, without dark markings. Mesonotal bristles very long, black ; scales narrow, dark brown ; no pre-alar line of flat scales ; two bare lines between the rows of bristles. Proepimera and sternopleura with a few light brown flat scales. One spiracular bristle. *Abdomen* blackish brown above, light brown below, devoid of markings. *Legs* dark brown ; undersides of femora somewhat lighter. First segment of front tarsi of ♂ almost as long as the tibia, that of the ♀ distinctly shorter ; legs of ♂ otherwise unmodified. *Wings* with the scales all dark on the veins, outstanding scales translucent and lanceolate. Upper fork-cell only about a quarter as long as its stem. Wing-length, 2·5 mm.

*Type* ♂, Karwar, 13.x.1902 ; paratypes, 3 ♀, 12–14.viii.1902.

This is an obscure species, not very easy to recognise ; it is perhaps most nearly allied to *U. brevirostris*, Edw., and *U. obscura*, Edw., both of which have shorter

proboscis and palpi, and comparatively longer antennae in the ♀, these being fully one-third longer than the proboscis. *U. metatarsata*, Edw., is similar in coloration, but differs remarkably in the front legs of the ♂.

**Aëdes (Finlaya) cogilli,** sp. n.

♀. Differs from *A.* (*F.*) *gubernatoris*, Giles, as follows :—*Head* without a median pale stripe, the eye-margins narrowly silvery white. Pro-epimera bare, except for a small patch of silvery-white scales on the posterior margin. Anterior white patch of mesonotum somewhat larger and more silvery ; pre-alar white patches smaller. Scutellum with the median lobe densely covered with flat silvery-white scales ; lateral lobes with a few flat black scales. Second pale ring on mid tarsi much narrower than is usual in *A. gubernatoris* ; a rather well-marked pale spot at the junction of the second and third hind tarsal segments.

*Cotypes*, 2♀, Karwar, 6.x.1902 and 2.ix.1902.

**Culex (Micraëdes ?) khazani,** Edw.

I have recently described this species from a male collected by Khazan Chand at Pudupadi, S.W. India ; this male was somewhat immature and shrivelled, and did not allow of a precise description of all its characters. Dr. Cogill's collection contains two females, one of which is very perfect, and enables me to give a number of additional characters for the species.

*Head* with a broad margin of flat scales round the eyes ; posteriorly with a large area of narrow pale ones. Proboscis rather long for a *Culex*, being distinctly longer than the front femora. *Thorax* with the mesonotal bristles unusually long and strong, and extending the whole length. Integument of mesonotum dark brown ; a blackish brown patch, indistinctly margined, on each side just in front of the wings. Integument of pleurae pale, with a large blackish brown spot occupying the lower half of the mesepimera ; no dark line above this. Lower mesepimeral bristle small and pale. Scarcely any scales on pleurae. Scutellum with narrow dark brown scales like those of the mesonotum. *Abdomen* blackish brown ; venter only a little paler than the dorsum ; no trace of pale lateral spots. *Legs* blackish ; hind femora white almost to the tip on the outer side, and on the basal three-fourths on the inner side.

**Culex (Micraëdes ?) malayi,** Leic.

Numerous specimens. In some of the males the abdomen has a faintly banded appearance to the naked eye, the segments being thinly scaled towards the base.

**Culex (Culex) bitaeniorhynchus** var. **ambiguus,** Theo.

Numerous specimens, all of this variety. The type form was not represented in the collection.

**Culex (Culex) cornutus,** Edw.

Three males of this recently described species were present.

## F.—New Species from Northern and Eastern Australia.

**Aëdes (Chaetocruiomyia) spinosipes,** nom. nov.

*Chaetocruiomyia sylvestris*, Theobald, Mon. Cul. v, p. 196, 1910 ; nec *Culex sylvestris*, Theobald [= *Aëdes vexans*, Mg.], Mon. Cul. i, p. 406, 1901.

This and the new species diagnosed below have a very peculiar fan-like tuft of extremely long scales on the small rounded knob at the base of the wing, close to

its articulation with the thorax, and projecting forwards in the direction of the longitudinal axis of the wing. I am not aware of any other mosquitos which show this feature, and it may perhaps be used to define *Chaetocruiomyia* as a valid subgenus of *Aëdes*, which genus it resembles in all essentials. In describing recently the Indian *Aëdes pulverulentus* I suggested a possible affinity to *Chaetocruiomyia*, but the Indian species does not possess a basal scale-tuft on the wings and is more probably related to the subgenus *Ecculex*.

The type ♀ possesses only two postspiracular bristles, and the head is mainly pale-scaled. Another ♀, collected by Dr. A. Breinl on Palm Island, N. Queensland, and presented to the British Museum by the Imperial Bureau of Entomology, has four postspiracular bristles placed in a row (quite an unusual arrangement) and the head has more dark scales at the sides. The two examples agree as regards thoracic, abdominal and leg-markings.

**Aëdes (Chaetocruiomyia) humeralis,** sp. n.

♀. Differs from *A.* (*C.*) *spinosipes*, Edw. (type ♀) as follows :—*Head* more extensively dark-scaled at the sides. The white area on the front half of the mesonotum is divided into two portions by a rather broad light brown band. Legs not quite so stout as in *A. spinosipes* ; hind tibiae without any yellowish scales in the middle beneath ; third hind tarsal segment with a distinct white ring at its base.

QUEENSLAND : Brigalow Scrub, Burnett River, 1911 ; biting (*Dr. T. L. Bancroft*).

*Type* and four other ♀♀ in the British Museum ; presented by Mr. F. V. Theobald.

**Aëdes (Finlaya) auridorsum,** sp. n.

♀. Differs from *A.* (*F.*) *australiensis*, Theo., as follows :—Palpi longer, equalling nearly three segments of the antennal flagellum instead of only two. Scales on anterior two-thirds of mesonotum deep golden, not whitish. Abdominal tergites 6 and 7 almost entirely golden-scaled ; sternite 8 much larger and more prominent. The first mid tarsal segment instead of having merely a narrow white basal ring, is white on the upper surface for the basal two-thirds of its length ; the third mid-tarsal segment has a few white scales at its base. Hind tarsi with moderately broad white rings at the bases of the first three segments, last two segments dark, the last segment indistinctly paler than the penultimate. (The hind tarsi may be the same in *A. australiensis*, but are damaged in the type.)

♂. Coloration and scale characters as in the ♀. Palpi purplish black, equalling the proboscis in length, last two segments densely hairy. Hypopygium : side-pieces long and slender. Clasper moderately short, with rather short terminal spine. Claspette with long slender stem, the apical fourth narrowed, appendage with a very broad membranous expansion.

From the probably allied *Culex biocellatus*, Taylor, the new species differs in its entirely dark-scaled costa.

NEW SOUTH WALES : Sydney, 1915 (*Dr. E. W. Ferguson*), type ♀, presented to the British Museum by the Imperial Bureau of Entomology in 1915, and determined then provisionally as a variety of *A. australiensis*. QUEENSLAND : Brigalow Scrub, 1911, biting (*Dr. T. L. Bancroft*), 1 ♀, presented to the British Museum by Mr. F. V. Theobald in 1921 ; Eidsvold, 27.i.1914, reared (*Dr. T. L. Bancroft*), 1 ♂, 1 ♀, presented to the British Museum by the Imperial Bureau of Entomology in 1922, 1 ♀ in the Australian Institute of Tropical Medicine.

**Aëdes (Finlaya) quinquelineatus,** sp. n.

♀. *Head* with narrow golden scales on the nape and along the upper part of the eye-margins ; two patches of flat black scales above, and pale flat ones at the sides. Proboscis slender, slightly longer than the front femora, black-scaled, with a rather

narrow whitish band in the middle of the ventral surface. Palpi about one-fifth as long as the proboscis, black-scaled, the tips rather narrowly silvery. *Thorax* dark brown, the mesonotum with five about equidistant lines of narrow golden scales; median line forked well before the scutellum; intermediate pair almost interrupted in the middle, some scattered golden scales tending to connect their posterior halves with the lateral lines at this point. Scutellum rather thickly covered with small flat white scales. Prothoracic lobes with flat white scales. Pro-epimera covered with flat black scales, a few paler ones below. Pleurae with a few small patches of flat white scales. Mesonotal bristles numerous, rather long, light brown. *Abdomen* dark brown dorsally, the tergites with small pure white lateral and small ochreous median basal spots. Venter ochreous. Eighth sternite moderately large, pale yellowish, without scales. Cerci short, blackish. *Legs*: femora dark brown, with narrow ochreous lines in front running almost to the tips, hind femora also pale beneath towards the base; knee-spots conspicuous, silvery-white. Tibiae dark brown, the middle pair with a narrow ochreous line in front, tips dark. Tarsi with pure white rings at the bases of the first two segments, the hind tarsi also with similar rings on the third and fourth segments, fifth dark; the rings just extend, on the upper surface, on to the tips of the segments. Front and middle claws toothed. *Wings* with dark brown scales, outstanding ones linear. Bases of forks level. Wing-length, 3 mm.

Queensland: No exact data (*Dr. T. L. Bancroft*, 1911).

*Type* ♀ presented to the British Museum by Mr. F. V. Theobald in 1921.

This species differs from *A.* (*F.*) *notoscriptus* in the markings of the mesonotum, and in many other points; from all the Oriental species (*macdougalli*, Edw., *trilineatus*, Theo., etc.) which somewhat resemble it, it differs conspicuously in the scaling of the scutellum.

**Aëdes (Finlaya) pecuniosus,** sp. n.

Differs from *Calomyia priestleyi*, Taylor, as follows:—Vertical bristles golden, not black. Pale scales of thorax metallic silver rather than white; a double median row of flat silvery scales extending from the front margin to a little in front of the scutellum, joining the patch which precedes and surrounds the bare space; a small patch of similar scales on the front margin on either side of the anterior end of the median line; sublateral lines on posterior third of mesonotum composed of broad, flat instead of narrow, spindle-shaped scales, and reaching forward to join the large silvery patches. Abdominal tergites with complete silvery-white basal bands, the last two almost entirely silvery. First two segments of front tarsi, and first three of mid and hind tarsi with basal white rings.

Northern Territory: Port Darwin (*C. L. Strangman*), type ♀ presented to the British Museum by Lt.-Col. A. Alcock in 1913.

The specimen was determined at the time as probably *Molpemyia purpurea*, Theo., but the type of Theobald's species shows no trace of the median line of silvery scales on the mesonotum. The three forms, *pecuniosus*, *purpurea* and *priestleyi*, form a very distinct group, and though closely related are probably specifically distinct. *A.* (*F.*) *purpureus* is intermediate between the other two, agreeing with *priestleyi* in its dark vertical bristles and in its thoracic ornamentation, but with *pecuniosus* in its abdominal and leg markings. Although none of the males are known, the species are probably referable to the subgenus *Finlaya*.

**Aëdes (? Skusea) aurimargo,** sp. n.

♀. *Head* with a rather narrow area of narrow golden scales in the middle reaching from occiput (where it is broadest) to vertex; on each side of this a few flat creamy scales, then a large patch of black, then a smaller patch of ochreous, then black again, no narrow scales round eye-margins. Eyes separated by the width of

two or three facets. Bristles dark brown. Clypeus dark brown, bare. Tori ochreous, with a few small golden scales. Proboscis black-scaled, slender, but scarcely longer than the front femora. Palpi black-scaled, nearly a quarter as long as the proboscis. *Thorax* with dark brown integument. Prothoracic lobes with some flat scales in front, narrow golden ones behind. Pro-epimera densely clothed with flat creamy scales below, narrow golden ones above. Mesonotum with small narrow, curved scales; dorsally black, sides rather broadly golden; a narrow central golden line running the whole length, and a pair of shorter golden lines in front of the scutellum. Pre-scutellar bristles small; no bristles on disc. Mid lobe of scutellum with flat black scales on the basal half, flat creamy ones on the apical half; lateral lobes each with a few broadish curved creamy scales. Pleurae for the most part densely clothed with flat greyish-white scales; postspiracular area with a small patch of narrow curved golden scales; bristles all pale; four pro-epimeral, about six post-spiracular, two lower mesepimeral. *Abdomen* with the first tergite black dorsally, white laterally; tergites 2–7 with small median basal creamy spots, diminishing in size from the second to the seventh, and with large basal creamy lateral spots; venter creamy. Seventh segment as long as the sixth, but narrower; eighth rather small and retracted, but the sternite visible, densely clothed with short pubescence; cerci short and rounded. *Legs* slender, purplish black, femora pale beneath basally; the hind femora also laterally to about four-fifths. No pale knee-spots. All tibiae about equal in length; first hind tarsal segments as long as the tibia. Claws all simple and rather small. *Wings* with purplish black scales, outstanding ones linear to somewhat clavate (on upper fork-cell) with square ends. Fork-cells a little longer than their stems, base of upper a little nearer the apex of the wing than that of the lower. Wing-length 3 mm.

N. Australia: Moa Island (*G. F. Hill*, No. 1520).

*Type* ♀ (unique) in the Australian Institute of Tropical Medicine.

A very distinct species, with some resemblance to *A.* (*S*). *funerea* var. *ornata*, but with quite different abdominal and more sharply defined thoracic markings, different scutellar scaling, etc. The thoracic adornment is very similar to that of the Javan *Armigeres* (*Scutomyia*) *treubi*, de Meij., which differs in its stouter proboscis, shorter hind tibiae, toothed claws, etc.

### **Culex (Lophoceratomyia) hilli**, sp. n.

*Head* clothed almost entirely with flat black scales (not easy to see on account of their colour), pale flat ones low down at the sides, and a small patch of brown narrow curved ones in the middle, just reaching the vertex. Proboscis and palpi black-scaled, the latter slender, bare, in the ♂ slightly longer than the proboscis, in the ♀ about one-sixth as long as the proboscis. A distinct thumb-like process at the base of each ♂ palp. Antennae of ♂ with the tori shiny black, bare, without prominence on the inner side; segment 2 nearly twice as long as broad, 3–9 about as long as broad; 10–12 each rather longer and more slender than the preceding; 13 twice as long as 14, 13 and 14 together about equalling 2–12 together; 6 with an outer row of four or five rather short and inconspicuous scales, the uppermost one rather longer and broader than the others, which are almost hairlike; 7 and 8 with the usual short twisted tufts; 9 with the usual long matted tuft; 10 with four or five long scales, broadest a little before the long sharp tips, directed externo-ventrally; 11 with four or five long hair-like scales, directed ventrally. *Thorax* with blackish brown integument, clothed rather densely with small dark brown curved scales and black bristles. Pleurae shining, somewhat lighter in colour than the mesonotum, with a few very small patches of inconspicuous pale scales; bristles black: four pro-epimeral, six rather widely spaced sternopleural, four or five pre-alar, one lower mesepimeral, two or three small upper mesepimeral, no spiracular. *Abdomen* black dorsally, the tergites with very small whitish basal lateral spots,

venter greyish white. Male clasper rather small, sickle-shaped, not at all swollen in the middle. *Legs* black, femora pale at the base beneath, no trace of pale knee-spots. Larger claw on front legs of ♂ toothed, all the remaining claws simple. *Wings* with blackish scales, which are rather denser than usual; most of the outstanding scales somewhat clavate. Wing-length, 2 mm. (♂)–2·6 mm. (♀).

NORTHERN TERRITORY: 70 miles south from Darwin (*G. F. Hill*, No. 1508).

*Type* ♂ in the British Museum, presented by the Imperial Bureau of Entomology; paratypes ♀ in British Museum and Australian Institute of Tropical Medicine.

This species is almost certainly identical with *Neomacleaya australis*, Taylor, described from N. Queensland, but that specific name is preoccupied in *Culex* by *C. australis*, Erichson. The nearest ally seems to be the Malayan *C.* (*L*). *quadripalpis*, Edw., which differs in its lighter colour, hairy ♂ palpi, and slightly different antennal characters.

**Culex basicinctus,** Edw.

I proposed this name (Bull. Ent. Res., xii, p. 78, 1921) for some specimens sent by Mr. G. F. Hill from Queensland as *Leucomyia annulirostris*, Taylor, but which I believed to be *Leucomyia annulata*, Taylor; I believed the new name to be necessary because *L. annulata* was preoccupied by *Theobaldia* (*Culex*) *annulata*, Schrank, *Culex* (*Trichopronomyia*) *annulata*, Theobald, and *C.* (*Culiciomyia*) *annulata*, Theobald. It now appears that the specimens before me were not Taylor's *L. annulata*, nor were they his *L. annulirostris*, but a distinct and hitherto undescribed species. I am indebted to Mr. G. F. Hill for the loan of the types of both Taylor's species. The type male of *L. annulata* has unfortunately lost the tip of its abdomen, but is almost certainly identical with *Leucomyia vicina*, Taylor; this again may prove the same as Skuse's *Culex annulirostris*, Theobald's interpretation of this species being certainly incorrect. Taylor's *Leucomyia annulirostris* is a distinct species, but is identical with his *Culicada squamosa*, as I have ascertained by comparison of the types.

Since my name *Culex basicinctus* was actually proposed as a substitute for *Leucomyia annulata*, it might perhaps be strictly logical to place it now as a synonym of *C. vicinus*; but in proposing the name I mentioned some diagnostic characters of the species I had wrongly determined as *L. annulata*, and this fact will perhaps be sufficient to permit the retention of the new name for the new species. The synonymy of the three species concerned will therefore be as follows:—

| | | |
|---|---|---|
| *Culex basicinctus*, sp. n. | *Culex vicinus* (Taylor). | *Culex squamosus* (Taylor). |
| | *Leucomyia vicina*, Taylor. | *Culicada squamosa*, Taylor. |
| | *Leucomyia annulata*, Taylor. | *Leucomyia annulirostris*, Taylor. |
| | ? *Culex annulirostris*, Skuse. | *Culex taylori*, Edw. |

I append a description of *C. basicinctus*.

*Head* clothed on the vertex with narrow creamy scales; a patch of flat black ones towards each side, flat whitish ones outside these. Proboscis short, not much more than half as long as the abdomen, black-scaled, with a sharply defined whitish ring slightly beyond the middle and about a fourth as long as the proboscis; in the ♂ a small tuft of pale hairs at the base of the ring beneath. Palpi of ♂ with the long segment nearly as long as the proboscis; a narrow whitish ring at the constriction; a broad white ring in the middle of the second portion; apical third with long black hairs on the outer side; last two segments black-scaled, narrowly ringed with white at the base; last segment with the apical third white, two or three terminal black bristles; no white scales beneath on the black portions. Palpi of ♀ rather stout, about one-quarter as long as the proboscis. *Thorax*: mesonotum with the anterior two-thirds mostly covered with whitish or dull ochreous narrow scales, the anterior third with a variable amount of darker brown scaling;

posterior third mostly dark-scaled except on and in front of the scutellum. A patch of erect flat scales a little in front of the root of each wing, the anterior ones white, the posterior ones black. Prothoracic lobes with black and white flat scales ; pro-epimera with narrow whitish scales ; no post-spiracular scales ; sternopleura and mesepimeron each with two patches of flat white scales ; no lower mesepimeral bristle. *Abdomen* blackish-scaled dorsally ; all the tergites with basal white bands which are broadened in the middle, especially in the ♀ ; tergites 5-8 with narrow apical creamy banding, sometimes hardly perceptible ; tergites 6–8 in ♂, 7–8 in ♀, with the sides continuously white. Venter white, with two large black spots on each sternite, sometimes uniting to form a band. *Hypopygium* : side-pieces uniformly hairy ; lobe small, with two short, pointed spines, but no distinct leaf ; clasper short, rather stout, sickle-shaped. Tenth sternites broad, rather short, with a large terminal patch of fine hair, not spines ; no basal arm. Lobes of mesosome with two distinct divisions ; upper division broad, with one long downwardly directed point, and one shorter one nearer the base ; lower division a simple outwardly-directed sickle. *Legs* : femora mottled, the dark scales predominating on the front and middle pair, hind femora paler ; small but distinct knee-spots present. Tibiae dark, with narrow pale tips ; middle and hind pairs with narrow anterior and broader posterior white stripes. Tarsi with rather broad white rings at the bases of the first four segments, the white not extending to the tip of the preceding segment ; on the hind legs the ring on the third segment is slightly broader than the others and occupies nearly one-third of the segment ; the fifth segment also has a narrow white basal ring. *Wings* with the scales all dark ; outstanding ones linear ; base of upper fork-cell slightly nearer wing-base than that of lower. Wing-length, 3·5–5 mm.

QUEENSLAND : Townsville, in house, 9–10.vi.1920 (*G. F. Hill*), 6 ♂ (including type), 6 ♀, presented by the Imperial Bureau of Entomology ; Eidsvold, xi.1911 (*Dr. T. L. Bancroft*), 14 ♂, 1 ♀, presented by Mr. F. V. Theobald.

## G.—A NEW *Armigeres* FROM THE NEW GUINEA REGION.

**Armigeres lacuum,** sp. n.

*Head* mostly black-scaled in ♀, with a narrow white border to the eyes and a small white spot on the vertex ; in ♂ the white markings are more extensive, and the black is less intense. Clypeus in ♂ apparently bare ; in ♀ with two patches of small flat white scales. Tori with small flat white scales Palpi blackish, about one-fifth as long as the proboscis in ♀, a little longer than the proboscis in ♂. Proboscis shorter than the front femora in both sexes, but in the ♀ it is more slender than usual in this genus. *Thorax* blackish brown dorsally ; a narrow white margin of narrow scales, more distinct in ♂ than in ♀ ; in ♂ also there is a whitish mark on the mid lobe of the scutellum, extending forwards a short distance, which is not present in ♀. Prothoracic lobes and pro-epimera with narrow white scales, broader below than above, and broader in ♂ than in ♀. *Abdomen* blackish dorsally ; tergites 1–7 with large rounded lateral white spots ; tergite 8 with a dorsal white spot. Venter white, sternites mostly with narrow apical black bands. Male hypopygium : side-pieces rather stout, pointed ; basal lobes not prominent, represented by a dense tuft of moderately long hairs, four or five of the most apical of which are thickened, almost spine-like. Claspers slender, slightly curved, slightly tapering at the tip, with about 20 equal-sized teeth. Tenth sternites moderate, simple, pointed. Lobes of mesosome scarcely crenulate apically. *Legs* blackish ; femora white beneath ; hind femora white to the tip on the outer side ; all tibiae about equal in length ; first hind tarsal segment about one-third shorter than the tibia. Claws normal, the middle pair in the ♂ being small, equal and toothed. *Wings* normal. Wing-length, 3·5–4 mm.

Ile des Lacs, E. of New Guinea (*Biró*, 1900–1901).

Type ♂ in Budapest Museum ; paratypes, 1 ♂ (without abdomen) 23 ♀, in Budapest Museum and British Museum.

The species is closely allied to *A. confusus*, Edw., differing in the much narrower white margin to the mesonotum in the ♂; denser hairs on the basal lobes of the side-pieces, and less crenulate mesosome; also in the possession of narrow dark bands on the sternites. It is possible that the ♀♀ are not conspecific with the ♂♂.

### H.—On the Genera *Bironella* and *Leptosomatomyia*.

These two genera were erected by Theobald in 1905 (Ann. Mus. Nat. Hung, iii, pp. 69 & 110) for species from New Guinea represented in the Hungarian National Museum. Neither species has been found again since, and the exact systematic position of both has been a matter of some doubt. Recently, through the kindness of Dr. K. Kertész, I have re-examined the types and mounted the male hypopygia of each, and am therefore able to throw some further light on these interesting species. I give below the characters not mentioned or left doubtful in Theobald's descriptions.

**Bironella gracilis,** Theo.

♂. Palpi scarcely shorter than the proboscis (not only two-thirds the length, as stated by Theobald), the last segment not very much swollen. Last two segments of antennae scarcely any longer than the preceding two or three, which are slightly longer than the rest. Head and thorax both shaped as in *Anopheles*. Mesonotum somewhat shining, not darker at the sides, without any scales; abdomen also devoid of scales. Legs covered with small scales. Wing membrane with well-marked microtrichia.

Hypopygium: side-pieces short and stout, less than twice as long as their width at the base, basal membrane large and apparently striated; from the outer basal corner of each side-piece arises a stout curved finger-like process, which is more than half as long as the side-piece, finely pubescent towards its base, otherwise bare, its apical half strongly chitinised, tip blunt and slightly lobed. Apart from these processes, there are no spines on the side-pieces. Claspers rather long, nearly cylindrical, with a post-median lump on the outer side, terminal claw short and broad. Ninth tergite a narrow, transverse oval, posterior margin simple. Anal segment membranous, elongate-conical, two-thirds as long as the side-piece. Aedoeagus (theca) a long, slender, cylindrical tube, with a single pair of reflexed leaflets at its tip, the leaflets a little over a quarter as long as the tube.

The above data are sufficient to establish *Bironella* as a distinct genus of the Anophelini, the position assigned to it with some doubt by Theobald.

**Leptosomatomyia lateralis,** Theo.

♂. Proboscis shorter than the abdomen, but not swollen at the tip. Eyes touching. Last two antennal segments together about half as long as the rest of the flagellum, and with longer pubescence, last longer than penultimate; basal flagellar segments with median whorls only, no short hairs at the tips, scarcely swollen in the middle. Flat scales of head reaching the middle line in front, surrounding the patch of narrow scales, but there is a row of narrow scales on the eye-margins at the sides, not shown in Theobald's diagram. The specimen is pinned from the side, and the pleural bristles are largely obscured, especially in the spiracular and post-spiracular areas; there are several pro-epimerals, and about five lower mesepimerals. The pro-epimera have broad white flat scales below and some narrow ones above. Hind tibiae very slightly longer than the front ones; first hind tarsal segment very slightly longer than the tibia; hind claws very minute; no pulvilli (?). Vein Sc ending just before the apex of Rs; Cell $R_2$ not at all narrowed apically; posterior cross-vein not unusually short.

Hypopygium: ninth tergite forming a narrow strip, scarcely divided in the middle, with short hairs. Side-pieces a little over twice aas long as their greatest breadth, outer face scaly, lower face with a patch of hair; on the upper side of the

inner face a rather large hairy median lobe, and on the lower side just before the middle two rather long spines, close together, placed on tubercles. Claspers rather stout, curved, grooved on the outer side, terminal claw stout and rather short. Tenth sternites strong, black, ending in a single sharp point. Parameres very small; mesosome of two lobes, each apparently with a single small subapical tooth.

I consider that the available evidence suggests that *L. lateralis* should be placed in *Aëdes*, perhaps in a distinct subgenus.

## I.—The Culicid Fauna of New Caledonia.

The first record of the occurrence of Culicidae in New Caledonia is that of Laveran (C.R. Soc. Biol., lii, p. 568, 1901), who describes *Culex kermorganti*, and mentions the occurrence of other species, among which there were no *Anopheles*. Later, Theobald (Nova Caledonia, i, p. 164, 1913) records the occurrence of *Culex jepsoni*, Theo., *C. nocturnus*, Theo., and *Chrysoconops acer*, Theo., and describes as new *Culex nocturnus* var. *niger*. So far as I am aware there are no other records of New Caledonian mosquitos.

A small collection was made on the island by the late Paul D. Montague in 1914, and the specimens comprising it have recently been presented to the British Museum. Five species were included, only one of them being among those previously recorded, two others being the common domestic species *Culex fatigans* and *Aëdes argenteus*.

With the necessary changes in nomenclature, the list of the Culicid fauna of New Caledonia as now known may be given as follows:—

*Mucidus kermorganti* (Laveran).
*Aëdes* (*Stegomyia*) *argenteus*, Poiret.
*Aëdes* (*Ochlerotatus*) *vigilax* (Skuse).
*Aëdes* (*Finlaya*) *notoscriptus* (Skuse).
*Taeniorhynchus* (*Coquillettidia*) *brevicellulus*, Theo.
*Culex sitiens*, Wied.
*Culex fatigans*, Wied.
*Rachionotomyia caledonica*, sp. n.

**Mucidus kermorganti** (Laveran).

*Culex kermorganti*, Laveran, C.R. Soc. Biol., liii, p. 568 (1901).

I am indebted to Mr. E. Séguy, of the Paris Museum, for enabling me to examine two female specimens of this species, and for presenting one of them to the British Museum. This latter specimen is from Calama, 1869 (*Delacour*). The scales of the abdomen and legs are rather small and all closely appressed, so that at first sight the species appears very distinct from its congeners. Apart from this striking difference, however, the species is extremely similar to *M. alternans* (Westw.), the structural characters and colour markings being the same. An analogous case is that of *Psorophora ciliata*, F., and *Ps. ctites*, Dyar, which differ in a similar manner.

**Aëdes (Ochlerotatus) vigilax** (Skuse).

*Culex vigilax*, Skuse, Proc. Linn. Soc. N.S.W. (2) iii, p. 1731 (1889).
*Culex marinus*, Theobald, Mon. Cul. i, p. 396 (1901).
*Culex pseudovigilax*, Theobald, Mon. Cul. iv, p. 382 (1907).
*Culex annuliferus*, Ludlow, J.N.Y. Ent. Soc., ii, p. 141 (1903).
*Culex ludlowi*, Blanchard, Moustiques, p. 630 (1905).
*Culex noctornus*, Theobald, Mon. Cul. iii, p. 159 (1903).
*Culex nocturnus* var. *niger*, Theobald, Nova Caledonia, i, p. 164 (1913).

Although I have seen males only from Queensland and the Philippines, I have no doubt that all the above names refer to one species. Since it appears to breed habitually in sea-water, it is not at all surprising that it should have attained a wide

distribution. Several specimens were collected by Mr. Montague, which agree well with Queensland examples. I have also seen the species from Formosa (Anping, *Sauter*) and Siam (Patani Cape, *Robinson* and *Annandale*).

**Aëdes (Finlaya) notoscriptus** (Skuse).

A single female was collected by Mr. Montague 15 miles inland on the Houailou River. I can see nothing to separate it from the common Australian species. *A. notoscriptus* is a widely distributed species, having been recorded from Australia and New Guinea, and quite recently from New Zealand by Mr. D. Miller. It is subject to considerable variation, especially in New Zealand, where the white thoracic lines are in some specimens entirely replaced by golden ; the last hind tarsal segment may be either white or black, or dark above and pale below.

**Taeniorhynchus brevicellulus,** Theo.

Recorded by Theobald (as *Chrysoconops acer*) from a single female in alcohol. The species is known to occur from Queensland to India, but apparently not in New Zealand, Walker's type of *Culex acer* being probably an abraded *C. fatigans*.

**Culex sitiens,** Wied.

I have not seen New Caledonian examples of this species, but it is most probably the species which Theobald has recorded as *C. jepsoni* ; the type of *C. jepsoni* is a female from Fiji, and is almost certainly *C. sitiens*, but another similar species also occurs in Fiji, and it is possible that this may be the New Caledonian species, or both may very likely occur. *C. sitiens* is a common salt-marsh species extending from Queensland to Somaliland.

**Rachionotomyia caledonica,** sp. n.

*Head* mostly black-scaled ; a narrow but conspicuous white margin to the eyes. Vertical and orbital bristles long, black, the former not very widely separated from the latter. Clypeus brown, bare. Proboscis very long and slender, considerably longer than the long front femora, entirely dark-scaled. Palpi dark-scaled, in ♂ about three-quarters as long as the proboscis, very slender and practically hairless, last two segments about equal in length ; in ♀ nearly twice as long as the clypeus. Antennae about three-fifths as long as the proboscis ; in ♂ strongly plumose, the last two segments less than half as long as the remainder ; in ♀ with very long verticils except on the last few segments. *Thorax* : integument of mesonotum rather light brown ; considerably denuded, but the remaining vestiture shows that it was densely covered with small, dark brown, narrow curved scales, in the middle, the anterior and lateral margins with longer, very narrow and slightly curved white scales, and a few broad flat ones in front of the wing-roots. Scutellum with small flat dark brown scales. About five pairs of dorso-central bristles. Pleural integument with two longitudinal dark brown unscaled stripes, the equally broad pale stripe between them clothed with flat white scales. Prothoracic lobes dark brown, clothed with flat white scales. Pro-epimera dark brown, nearly bare (perhaps denuded). One pro-epimeral bristle ; two or three spiraculars ; one small upper sternopleural. Postnotum light brown, bare. *Abdomen* : first tergite with dark brown scales, second and third with dark brown scales and narrow apical white bands of even width (remainder of abdomen missing). *Legs* long and slender, dark brown, unmarked except that the femora are light on their undersides towards the base. Hind tibiae a little shorter than the others ; first hind tarsal segment about one-fourth longer than the tibia. Claws on front and mid legs of ♂ unequal, the larger claw on the front legs with a small tooth about the middle ; remaining claws all simple ; two very small ones on hind legs. *Wings* with dark brown scales, the outstanding ones linear, not very numerous. Upper fork-cell about twice as long as its stem, its base slightly nearer the base of the wing than that of the lower. Cross-veins separated by twice the length of the posterior. Wing-length, 3 mm. (♂)–3·5 mm. (♀).

*Cotypes*, 1 ♂, 1 ♀, Houailou, 31.vii. and 1.viii.1914 ; bred from pitcher of *Nepenthes*.

I have referred this form to *Rachionotomyia* rather than to *Rachisoura* or *Mimeteomyia* on account of the long slender proboscis and the breeding habits. The long ♂ palpi, however, are unusual in this genus and are not found in any Oriental species. The presence of well-marked dorso-central bristles is noteworthy, since these bristles are otherwise present only in the *Colonemyia* group of *Rachionotomyia* and not in *Rachisoura* or *Mimeteomyia*. The new species, however, lacks the conspicuous ornamentation of the *Colonemyia* group.

## J.—Errors and Omissions in my Paper on the Palaearctic Mosquitos.*

Immediately before my paper appeared in print, descriptions were published by Mr. S. Yamada of ten new species of *Aëdes* from Japan.† Three of these were recorded only from Formosa, but the following should be added to our list of Palaearctic species :—

| | |
|---|---|
| *Aëdes galloisi*, Yam. | Subgenus *Stegomyia*, near *S. albopictus*, Skuse. |
| ,, *flavopictus*, Yam. | ,, ,, ,, |
| ,, *chemulpoensis*, Yam. | ,, ,, ,, *S. fraseri*, Theo. |
| ,, *watasei*, Yam. | ,, *Finlaya*, ,, *F. melanopterus*, Giles. |
| ,, *seoulensis*, Yam. | ,, ,, ,, *F. gubernatoris*, Giles. |
| ,, *omurensis*, Yam. | ,, *Ecculex*, synonymous with *E. alboscutellatus*, Theo. |
| ,, *esoensis*, Yam. | ,, *Aëdes*, near *A. cinereus*, Mg. |

Mr. Yamada has kindly shown me his types, and I can confirm the distinctness of all the species (except *A. omurensis*) from previously described forms. All except *A. esoensis* are of Oriental affinities.

The following further corrections and additions should be noted :—

Page 263. In making my acknowledgments I unfortunately omitted the names of several correspondents who had assisted me with specimens. These were : Dr. M. Langeron, Paris ; Mr. G. Boag, Aguilas, S. Spain ; Mr. A. Tonnoir, Brussels Museum ; Mr. M. P. Riedel, Frankfurt a. M. ; Major S. R. Christophers, Kasauli, India.

Page 264. The researches of Mr. Yamada indicate that the boundary between the Oriental and Palaearctic types of mosquito fauna in Japan is between the islands of Honshu and Hokkaido, or roughly the 40th parallel of latitude. The mountains of northern Honshu also seen to have the Palaearctic type of fauna.

Page 265. *Aëdes salinellus* should have been mentioned in the list, with an American representative in *A. impiger* (*decticus*).

Page 272. Mr. Stanley B. Freeborn has called my attention to a paper (Journal of Parasitology, vii, pp. 67–79, 1921) in which he and Prof. Herms have described the eggs of *Anopheles occidentalis* (under the name *A. quadrimaculatus*). These resemble those of *A. maculipennis* except that the average number of divisions in the lateral floats is smaller (12 instead of about 16). This confirms the status of *A. occidentalis* as at most a variety of *A. maculipennis*.

Page 279. Dr. M. Langeron (Archives de l'Inst. Pasteur de l'Afrique du Nord, i, pp. 347-382, 1921) has briefly described the larva of *A. sergenti*. It resembles *A. culicifacies* and *A. funestus* in having palmate hairs on each of the first seven abdominal segments and on the thorax. He does not mention the abdominal scuta, the size of which would decide to which of these species *A. sergenti* is more nearly related.

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* Bull. Ent. Res. xii, pp. 263–351, 1921.
† Annot. Zool. Japon. x, pp. 45–81, 1921.

Page 283. Dr. Langeron, in the papér just cited, records larvae of *Uranotaenia unguiculata* from Southern Tunis.

Page 287. A brief description of the larva of *Theobaldia alaskaensis* has been given by Dyar (Insec. Inscit. vii, p. 33, 1919). It differs from *T. annulata* in the siphonal index (2·5 instead of 3–3·5).

Page 303. I am indebted to Lt.-Col. W. P. MacArthur for two larvae and a perfect female of *A. zammitti*. The larvae are obviously distinct from those of *A. mariae*, from which they differ in the points I have emphasised. The white stripes on the thorax of the female are very distinct, and are connected by small white areas with the lateral margins. The abdomen has very distinct traces of a median longitudinal dorsal stripe, thus approaching rather closely to *A. caspius* in appearance, though differing in the pure white basal segmental bands.

Page 304. The Parisian specimens of *A. pulchritarsis* have been described by Séguy as *A. berlandi* (Bull. Soc. Ent. France, 1921, p. 192). I consider the form to be at most a variety of *A. pulchritarsis*.

Page 310. Dr. H. G. Dyar, who has compared numerous specimens of adults and larvae, is of opinion that *A. rostochiensis* is specifically distinct from *A. cataphylla*.

Page 314. The absence of a spine on the basal lobe of the male side-piece will not distinguish *A. parvulus* from *A. alpinus*. It is really absent or extremely weak in *A. alpinus* also.

Page 319. The name *Culex wahlgreni*, Theobald, should be added to the synonyms of *Aëdes geniculatus*. It was proposed (Mon. Cul. v, p. 396, 1910) as a substitute for *C. fusculus*, Wahlgren (Ark. Zool., 1905). Wahlgren, however, did not introduce the name *fusculus* but merely remarked on Zetterstedt's types.

Page 325. According to Mr. Yamada it is doubtful if *A. argenteus* occurs in Japan proper. There may have been some mistake in Theobald's record ; the specimen on which it was founded is not now in the British Museum.

Page 330. Under heading 16 in the key the names of the species were accidentally reversed. *C. vishnui* is the species with the long tooth on the mesosome.

Page 336. The name of Yamada's species is incorrectly spelt. It should be *C. hayashii*. The correction should be made also in other places where the name is used.

Page 342. I feel almost certain that Ingram and Macfie have figured an immature larva of *C. quasigelidus* by mistake for the larva of *C. univittatus*, and fully anticipate that breeding experiments will eventually prove the identity of *C. perexiguus* and *C. univittatus*.

# NOTES ON THE COCONUT BEETLE (*ORYCTES MONOCEROS*, OL.) IN KENYA COLONY.

By F. W. Dry.

The present notes are a short account of work of a preliminary nature on the Coast of Kenya Colony, mostly between August 1920 and February 1921, at the end of a tour of service, and may serve to indicate some of the chief points calling for investigation. They are concerned with the life-history of the insect and with some field observations. The life-history work was carried out in tents shaded by a large mango tree, on land kindly lent by Sheik Ali bin Salim, on the north side of Mombasa Island. The field work was done on the island and on the neighbouring mainland. For records of the numbers of beetles captured on European plantations I am indebted to three gentlemen owning or managing them.

## The Life-history of the Coconut Beetle.

*The Egg.*—For thirty records of the length of the egg stage the average time was 15 days, the minimum being 12 days and the maximum 20. Of the eggs deposited in confinement two-thirds did not hatch. Eggs have not been laid by the beetles in captivity at all readily. In the field the beetles feed on the "cabbage" at the top of the palm, so that laboratory conditions were necessarily unnatural, the beetles being kept in two-pound biscuit tins, a pair in each. The tins were about a third filled with the powdery material from the inside of decaying coconut logs, in which eggs are mostly laid in the field. The beetles were kept provided with pieces of the husk of unripe coconuts or with bits of sugar-cane, on both of which they were found to feed readily. The powdery substance was searched through daily. The largest number of eggs obtained from one female, an insect bred in the laboratory and kept provided throughout life with a mate, was 30; she died after an adult life of 111 days. The next largest number was 15, from a female brought in from the field, and similarly kept provided with a mate. Quite a number of females that passed their whole adult life in the laboratory lived a long time, some more than a hundred days, without laying as many as fifteen eggs. When eggs were laid, it was usual to find several deposited the same day, frequently as many as seven, and sometimes nine, ten or eleven. In the field during the Short Rains (October to December) eggs were plentiful. It was quite common to find a single female beetle in a log with fifty or more eggs, and though there is no proof that these had all been laid by the one individual, eggs were sufficiently abundant in the field to suggest that under natural conditions the beetles lay many more eggs than they did in the laboratory.

*The Larva.*—The grub was the most difficult stage of the beetle to work with, the mortality always being high. The literature on *O. rhinoceros*, L., would seem to suggest that the same difficulty has been experienced with that insect. At first grubs were kept, singly or a few together, in small tins, the food being changed frequently and the grubs examined daily to see if they had moulted. Afterwards the grubs were handled less often, and greater care was taken to give food not containing many grub faeces. From grubs treated in this way some information was obtained about moults, but of these grubs not a single one hatched in the laboratory survived to pupate. Moults at three different sizes were observed, namely, when the breadth of the head capsule was $2\frac{1}{2}$ mm., 5–6 mm., and 10–11 mm. The breadth of the head capsule of a large number of grubs brought in from the field was measured, but none were found with measurements intermediate between those three sizes. Besides, a considerable number of grubs with head capsules of the largest size

(10–11 mm.) were brought in and fed, and none of them moulted except in the act of pupating. It would therefore seem that three is the number of moults, particulars about these being as follows :—

| | *Length of larvâ, about* | *Breadth of head capsule* | *No. of days after hatching, about* |
|---|---|---|---|
| On hatching .. | 6 mm. | $2\frac{1}{2}$ mm. | — |
| Moult i .. .. | 12 mm. | $2\frac{1}{2}$ mm. | 4 days. |
| Moult ii .. .. | 21 mm. | 5–6 mm. | 22 days. |
| Moult iii .. .. | 43 mm. | 10–11 mm. | 48 days. |

Approximate data for the length of the larval period were, however, obtained in the following ways. Grubs which had just hatched were placed in coconut logs beginning to rot, these logs having been boiled in a way found sufficient to kill all the contained beetle eggs and grubs. About half a dozen freshly hatched grubs were placed in each, all on the same day. They were kept in 4-gallon tins or in barrels and left undisturbed for some period such as 60 or 80 days. They were then split open and after being examined were tied up with any grubs they were found to contain still inside, or the grubs were placed inside other rotten logs, or kept in fibrous material from a decaying log in the tins. The mortality was again high, nine-tenths dying ; but treated in this way a small number of grubs hatched in confinement completed the larval stage by pupating. Figures giving a good indication of the length of the larval stage were obtained, too, from grubs hatched in the laboratory which died on the point of pupation. After the grub has reached its maximum length, when it has a very turgid appearance, it remains of the same size for some little time and then empties itself of food, becoming by degrees appreciably shorter and very flabby. Then about four or five days after this condition is reached, the insect pupates. Additional evidence was also procured by measuring, at frequent intervals, grubs of different sizes, from very small to very large, brought in from the field and fed until death or pupation, and then combining the figures so obtained. The figures found in these various ways all point to an average larval period of about 100 days. The shortest time between the hatching of the grubs which were put inside a log and the pupation of a grub subsequently recovered from the log was 82 days.

*The Pupa.*—The length of the pupal period was ascertained from large grubs brought in from the field and from a few grubs which passed the whole larval period in the laboratory. For 29 individuals the average length of the pupal period was 21 days, the extremes being 19 days and 28 days. In this work on the pupal period 14 pupae died, as well as 59 larvae in the flabby condition which precedes pupation. When the insects were kept in fibrous material a cocoon of this substance was generally constructed, but if the material they were living in was powdery no cocoon was made. The only place of pupation which I found in the field was inside or just below material in which the grubs had fed, but I was not then aware that Leefmans* had found the usual place of pupation of *O. rhinoceros* to be at a depth of 12 inches in the soil. Large grubs in confinement, especially in a few cases when kept in food badly fouled by their own faeces, have been found to tear the bodies of their fellows, which points to one advantage of the soil as a place for pupation.

*The Adults.*—As already explained, it was not practicable to keep the adult beetles under natural conditions in confinement, but in the conditions described the length of adult life was frequently long. Several individuals, of both sexes, brought in alive from the field, or becoming adult in the laboratory, lived in confinement for more than 100 days. Many lived more than two months, the maximum having been 125 days, for a male brought in from the field. Several pairs of beetles were taken *in copula* in chopping up decaying logs in the field.

* Leefmans, S., Die Klappertor (*Oryctes rhinoceros*, L.). Meded. Inst. Plantenziekten, Buitenzorg, no. 41, 1920.

Combining the times for the three immature stages of the life-history the data so far obtained point to a period of about four and a half months between the deposition of the egg and the emergence of the beetle. Sometimes, doubtless, the period is a little shorter than this, and more data may well show that it is often appreciably longer. Some observations were made as to how quickly a coconut log could become suitable for food for the grubs. On 10th March a number of logs about three feet long were seen to be thoroughly hard and unfit for food for beetle grubs. The weather was then very hot and dry, but the Long Rains began shortly afterwards and April was a very wet month. On 2nd August they were examined again and found to be thoroughly rotten, and a number of beetle grubs, including some in the last instar, were taken. The condition of the logs was just as if the grubs had been feeding there all their lives. At any rate coconut logs may quickly become breeding-grounds for the beetle.

## Records of Numbers of Beetles captured on European Plantations.

Information about the numbers of beetles collected by hand on three European coconut plantations on a known area and in a known time was kindly supplied by gentlemen owning or managing them. Collecting the beetles and not permitting breeding-places on the plantations are the usual methods of defence against the beetle.

Mr. A. S. Kerr placed at my disposal the records of collecting in three plantations on an estate on the coast at Gazi, 30 miles south of Mombasa. These plantations total about 1,250 acres, and allowing for gaps would contain something like 50,000 trees. At the end of 1920 the trees varied in age from just planted up to about six years, with just a few older trees. There were only a very few native-owned coconut trees near to the plantations. Collecting had been done before 1918, but the earlier records were not available. For the last three years the figures had been :—

| | |
|---|---|
| 1918 .. .. .. .. .. | 7,100 beetles. |
| 1919 .. .. .. .. .. | 5,340 ,, |
| 1920 .. .. .. .. .. | 632 ,, |
| Total .. .. | 13,072 ,, |

In 1918 and 1919 a boy's task was ten beetles a day. In 1920 it was not necessary to do much collecting and in October the beetles were so scarce that only two were required to be brought in for a day's work.

Mr. W. E. F. de Lacy gave me the figures for the whole of 1919 for a plantation at Changamwe, about four miles from Mombasa, on the mainland. The plantation contained 2,096 coconut trees, which, at 55 trees to the acre, would be equivalent to an area of 38 acres. It was adjacent to one excellently managed plantation, but was near to native-owned coconuts among which conditions were extremely favourable to the beetle. Mr. de Lacy had eliminated the breeding-places of the beetle from his plantation and believed that all the beetles captured there had been bred elsewhere. Boys were paid about a penny a beetle for each one brought in. The number captured during the year was 1,009.

Mr. James Paton supplied figures for the months from September to December 1920, for a young plantation of about 400 acres situated on the mainland about six miles from Mombasa, where he employs two boys for collecting beetles. The plantation is kept free from breeding-places. There are a few small native plantations near, but much of the adjacent area is mangrove swamp or other wild vegetation where it is unlikely that any number of beetles can breed. In the four months the boys collected 360 beetles.

It will be seen that the numbers of beetles captured per acre per annum are at the rate of about 3 for the first and last plantation and 26 for the second one.

The first plantation is the largest and the records cover the longest time. We may be sure that an appreciable proportion of the beetles present in the plantation were captured. The labour is well managed on the plantation, and with trees like the coconut palm, which is usually planted on this estate at the rate of 55 to the acre, every one can be examined. The boys readily recognise trees that have been attacked by the chewed material thrown out by the beetle and then look to see if the insect is still there. A good search, therefore, was made, and while other unknown factors may have helped to bring about the result, in the last of the three years the beetles were greatly reduced in numbers. It may thus safely be concluded that we are concerned with tens of beetles to the acre a year rather than with hundreds or thousands. Besides, the effects of attack by a single individual are quite perceptible, and it has already been mentioned that in confinement the beetles live a long time. With this species, therefore, every individual adult counts.

With the smallness of the number of adult individuals one at once correlates the fact that beetle grubs were much easier to obtain, as they were all the time that I was at the Coast. All the stages of the beetle were to be found at any time. I have no record of the relative numbers of beetles and grubs captured in a given area in a given time, but if a large number of grubs were wanted, two boys chopping up logs at Changamwe would collect a couple of hundred or more in a day, while at the same time it was economical to pay the natives at the same place about a penny for each beetle they brought in. In collecting the grubs dead ones were very often found, and the high mortality amongst the grubs is at any rate suggestive. A similar high mortality in the early stages has been found in other boring insects. For example, Dr. Van Someren, the Government Dentist at Nairobi, told me that he had found this to be so with the carpenter bee, *Xylocopa flavorufa*, de G., and Dr. E. Schwarz, in conversation at Washington recently, said that it is frequently so with boring beetles. While the limiting factors of the beetle remain to be investigated, it does look probable that mortality through overcrowding in the breeding-places is a factor that actually exercises what Howard calls "facultative control."

### A Comparison of the Extent of Beetle Damage in two Coconut Areas where Conditions affecting the Beetle were different.

A rough index of the extent of beetle damage in an area was obtained in a simple way. In boring holes into the "cabbage" at the top of the coconut tree the beetles in the great majority of cases cut across the pinnae of one or more leaves while they are still folded in the heart of the plant. Occasionally signs of attack can be seen on the stalks of the leaves without the pinnae being affected. When leaves with damaged pinnae unfold, and so long as they remain on the plant, they look as if portions have been neatly taken out by a person beginning to cut at some point on the edge and cutting in a straight line across the pinnae more or less at right angles to the stalk. All the pinnae as far as the stalk may be affected, or the attack may stop short of the stalk. Sometimes the pinnae on both sides of the stalk have been cut quite symmetrically. While weaver-birds sometimes produce a rather similar effect and the wind may sometimes injure the leaves, one can tell very fairly which leaves have been attacked. Counts of such leaves have therefore been used to get a rough index of the extent of beetle damage in a coconut area. The two areas to which this method was applied are strikingly different as regards conditions affecting the coconut beetle.

The first area is the mainland near Mombasa in the coconut area in non-European hands. A large number of holdings, mostly small, adjoin to make hundreds of acres of cultivated land where coconuts are mixed with other plants. The coconuts have mostly been planted in a haphazard way, and old and young trees are growing side by side. The grass is often long, but there is little bush. There are quite a number

of dead palms, and there was no evidence of any attempt to destroy them. At two places in this area the following counts were made :—

| *Place.* | *Trees.* | *Date examined.* | *Average No. leaves per tree.* | *Percentage trees attacked.* | *Percentage leaves attacked.* |
|---|---|---|---|---|---|
| Changamwe .. | .. 100 old trees .. | Jan. 1921 | 20½ | 100 | 21 |
| ,, .. | .. 100 young trees | ,, | 11½ | 55 | 11 |
| Kisauni .. | .. 100 old trees .. | ,, | 23 | 98 | 18 |
| ,, .. | .. 100 young trees | ,, | 13 | 58 | 13 |

By young trees are meant those up to about six years old.

The second area is the main plantation, 900 acres in area, on the estate at Gazi, for which particulars of beetle collecting have already been given. There were not many breeding-places for the beetle within the plantation, for any dead trees are at once destroyed and the land has been very fairly cleared of old stumps. In part of the plantation, by far the greater part in fact, labour having been insufficient, weeds and old rubber plants had grown up high, and such parts did show rather more beetle attack than the clean area. The plantation was almost surrounded by thick bush, a dense jungle of big palms and other trees. As already recorded, large numbers of beetles had been collected during the years 1918 to 1920. The palms had been planted at different times, the oldest being six years old, while a few had only just been planted out. The figures marked "A" are for two rows at right angles to each other running through the middle of the plantation from boundary to boundary. Those marked "B" are for the outside row circling the whole plantation. The following figures were obtained :—

| *Date.* | *Number of trees counted.* | *Average number of leaves per tree.* | *Percentage of attacked* | | *Percentage of attacked leaves which are* | |
|---|---|---|---|---|---|---|
| | | | *Trees.* | *Leaves.* | *Young.* | *Old.* |
| A. Oct. 1920 .. | 425 | 13½ | 19 | 2·3 | 19 | 81 |
| B. ,, .. | 784 | 12 | 41 | 6·4 | 42 | 58 |

In the native plantations it will be seen that almost every old tree shows beetle attack. On the old trees, I was told, a leaf will stay on the tree for about a year. On young trees the leaves remain on the plant longer. This emphasises the fact that old trees are attacked more than young ones.

At Gazi, comparing the two sets of figures from the plantation there, we find that in the outside row there is more beetle attack than in the inside. And further, in counting, I noted how many attacked leaves belonged, approximately, to the younger half of those on the tree, and how many to the older. In the outside row the proportion which are young is double that for the two rows running through the plantation. In the bush, from dead logs of different kinds eggs and larvae were obtained which I could not distinguish from those of the coconut beetle, but such eggs and larvae were found in small numbers only. They were taken chiefly from dead mukoma palms, and in this material other beetle grubs were much more plentiful, and they were living in material harder than any in which I have found coconut beetle grubs. From a pupa from a dead branch of mukoma which contained a score of these other grubs a beetle was reared which Dr. G. A. K. Marshall informs me is a Cetoniid, *Pachnoda euparypha*, Gerst. Bush like that adjacent to the Gazi plantation covers large areas in the Coast belt, and the whole question of the relation to it of the coconut beetle needs investigating. The few observations here recorded suggest that this bush, while a source of beetles, may not make a very favourable breeding-ground for them.

On comparing the figures for the two different areas, native plantations remote from thick bush, and European plantation near to bush, one is encouraged to conclude that were the native area kept free from breeding-places, instead of being badly infested with the beetle, it would suffer comparatively little attack.

# NOTES ON THE CALLIPHORINAE. PART I. THE ORIENTAL SPECIES

By Major W. S. Patton, M.B., F.E.S., I.M.S. (retd.),

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For many years I have collected and bred the Indian Calliphorinae, and recently contributed a number of papers describing the common species. In the first of these, which appeared in a recent number of the Indian Journal of Medical Research (viii, no. 1, July 1920), I described in some detail the egg, larva, puparium and adults of *Chrysomyia bezziana*, Villeneuve, the Old World screw-worm fly, and pointed out that this species is a specific myiasis-producing Calliphorine, only breeding in living tissues, and that its larvae may be found in all forms of cutaneous, subcutaneous, nasal, oral, aural and vaginal myiasis in man and animals. In the succeeding papers I described the larvae, puparia and adults of the other common species, two of which, *Chrysomyia megacephala* and *Lucilia argyricephala*, occasionally cause myiasis in animals in India. It was not possible at the time to determine the non-myiasis-producing species, and new names were given them. But recently, when studying the species of *Musca* in the National Collection at the British Museum, I was able to examine Walker's types and am now in a position to give these Indian species their correct names. At the same time I have examined all the Calliphorine material in the National Collection from other parts of the world, as well as many specimens in my own collection, and I propose in this and in succeeding notes to collect together all the results of my studies with a view to revising later the species of blow-flies. Here again I am deeply indebted to Major E. E. Austen, D.S.O., for the valuable help he has given me in this work.

As I have a large number of specimens of *Chrysomyia bezziana* and its larvae, as well as adults and larvae of all the other Indian species, I shall be very glad to exchange any of these species with any Dipterologist for specimens from other localities. In the present paper I record my preliminary studies of the Oriental species, and shall deal with those from other regions in subsequent notes.

1. **Chrysomyia bezziana,** Villeneuve.

Synonyms : *Chrysomyia dux*, Escholz (*apud* Sinton and authors).
*Chrysomyia flaviceps*, Macquart (of authors).

This species is rarely seen in its adult stage as it does not breed in decaying animal matter and is only attracted to diseased human and animal tissues. Almost every Medical and Veterinary Officer in India has, on the other hand, seen its larvae in all forms of myiasis in man and animals. Since my last record of the larvae of *C. bezziana* from human tissues, I have received four male specimens from Mr. T. Bainbrigge Fletcher, Imperial Entomologist, India, bred from wounds on the soft palate of a patient in the Pusa hospital. And in a recent paper Sinton (Ind. Jl. Med. Res. ix, no. 1, July 1921) records two cases of human myiasis —nasal and buccal— from Kohat, North West Frontier Province, India, in which he describes the larva from Case 1 clearly showing that it was that of *C. bezziana* ; and I have little doubt that those from Case 2 also belonged to this species.

*Chrysomyia bezziana* is the most important myiasis-producing Calliphorine in India, and now that its larvae have been fully described, Medical and Veterinary Officers should find no difficulty in recognising them when they come across them in the course of their work, and I hope that if they find any larvae which do not agree with these descriptions, that they will send them to me preserved in spirit. Any larvae of this species from other parts of the Oriental region other than India would be welcome.

2. **Chrysomyia megacephala,** Fabricius.

Synonyms : *Chrysomyia* (*Musca*) *dux*, Escholz.
*Chrysomyia* (*Lucilia*) *flaviceps*, Macquart
*Chrysomyia* (*Musca*) *remuria*, Walker.
*Chrysomyia* (*Musca*) *bata*, Walker.
*Chrysomyia duvaucellii*, Robineau-Desvoidy.

This species was originally described by Fabricius from Guinea, but so far as I am aware, it has not been recorded from that region again, unless it has been confused with *C. bezziana*, which also occurs in West Africa and is very like it. Wiedemann evidently examined Fabricius's type, a female, and gives a full description of it. I have carefully compared his description with a number of specimens, and, short of examining the type, consider in the meantime that *megacephala* is identical with Escholz's *dux*, and Macquart's *flaviceps*.

In describing his species Macquart draws attention to its close resemblance to the Fabrician species, but points out that *megacephala* is from Guinea while *flaviceps* is found in India, and that the former is much larger. I may, however, point out that these distinctions are of little or no value. There is nothing remarkable in the fact that the two localities are so widely separated, for *C. bezzianna* is found in West Africa as well as throughout India and probably China ; and size and colour are of no use whatever in separating these flies.

I have examined the type of Walker's *remuria*, a female, from China, and that of his *bata*, also a female, from an unknown locality, and find that both are typical examples of *megacephala*.

This species is extremely widely distributed, and I have in my collection typical examples of both sexes from the Australian region sent me by Mr. W. W. Froggatt and Mr. G. F. Hill. *Chrysomyia megacephala* is the common bazaar blue-bottle of India, and is always abundant on the meat and sweet stalls, and around toddy shops. Fletcher records its occurrence in large numbers on the toddy-palm spathes and pots, which it fouls with excrementitious matter. It breeds in all kinds of decaying animal matter. I have recorded its larvae from cases of animal myiasis. It would be interesting to know whether it ever attacks man.

I have no doubt that Robineau-Desvoidy's *Chrysomyia duvaucellii* from Bengal is this species.

3. **Chrysomyia albiceps,** Wiedemann.

Synonyms : *Chrysomyia* (*Musca*) *putoria*, Wiedemann.
*Chrysomyia albiceps* var. *bibula*, Wiedemann.
*Chrysomyia* (*Lucilia*) *rufifacies*, Guérin.
*Chrysomyia* (*Lucilia*) *orientalis*, Macquart.
*Chrysomyia* (*Musca*) *himella*, Walker.
*Chrysomyia* (*Musca*) *emoda*, Walker.
*Chrysomyia* (*Musca*) *elara*, Walker.
*Chrysomyia* (*Lucilia*) *bengalensis*, Robineau-Desvoidy.
*Chrysomyia dejeanii*, Robineau-Desvoidy.

I am still in doubt as to the true identity of Wiedemann's two species, *albiceps* and *putoria*, and I may say I am not alone in this respect, for Professor Bezzi determined my Indian specimens as *albiceps* and Dr. Villeneuve identical specimens as *putoria*.

*Musca albiceps* was described by Wiedemann in 1819 from the Cape, and the type specimen of *Musca putoria* is from Sierre Leone. Now, in order to settle as to whether these two species are distinct, I may say that both Major Austen and Dr. Villeneuve separate the males of *putoria* from those of *albiceps* on the structure of the front, which in *putoria*, according to these authorities is narrow, the eyes almost meeti ng

whereas the front of the male *albiceps* is wider, the eyes being separated by a distinct interval ; there are also other minor characters, such as the dorsum of the thorax of *putoria* being partly greyish pollinose, while that of *albiceps* is shining and not pollinose. Using these characters, I have examined a long series of both species from various localities, and in particular a small collection of *albiceps* taken by Major Austen from the Mount of Olives, Palestine : also many hundreds of specimens from India and Australia. The Palestine form differs from the Indian in the following respects :—The face in the Palestine females is much more silvery white, whereas it is of a dirty yellow colour in the Indian specimens ; the antennae of the Palestine species are not nearly so red as those of the Indian forms ; the palpi are darker orange, whereas those of the Indian ones are lighter orange ; the abdominal bands are narrower than in the specimens from India.

Most of the specimens collected on the White Nile and in Sierra Leone agree with the Indian form ; the African males, like the Indian, have a narrower front than those of the Palestine specimens. But on examining a series of specimens labelled *albiceps* in the National Collection, I note that there are males with fronts intermediate between the Palestine males on the one hand, and the African ones on the other, and that in some the abdominal bands are broad, broader than the Palestine specimens This collection also contains three specimens labelled *albiceps* var. *bibula*, Wiedemann, by Dr. Villeneuve from British East Africa and North West Rhodesia, and I can see no difference between these and the Indian forms named by that authority as *putoria*. Therefore without going any further into the identity of Wiedemann's two species, it is quite clear that there are two distinct forms which merge into each other, and for this reason I prefer in the meantime to place both under the name *albiceps*, including Wiedemann's variety *bibula*. As soon as I have completed my studies of the external genitalia of both sexes of these forms, I shall be in a position to express a final opinion as to whether they are to be considered distinct species or mere racial forms.

Major Austen kindly showed me some larvae which he collected among some weeds when searching for *Anopheles* larvae in Palestine, and on examining them macroscopically, I could see no difference between them and the larvae of the species from India. Both have the same type of fleshy processes with a tuft of spines at their apices, and short of examining them microscopically I consider they are identical. I am of course assuming that they are the larvae of *albiceps*, though there is no proof of this, as the flies were not bred from them. I trust those who have opportunities of collecting larvae of either form, but especially *albiceps*, will send me larvae for microscopic study.

There is an interesting specimen in the National Collection of what conforms to the *putoria* type, from Lourenço Marques, bred from a larva from an infected human sore. I have compared this specimen with the Indian and Palestine species, and find that the face is as white as that of the Palestine females, and the abdominal bands are broader. It is evident then that this form may cause human myiasis in man. I have no record of this hairy larva from human or animal tissues in India, though, of course, *Chrysomyia rufifacies* commonly attacks sheep in Australia.

*Lucilia rufacies* is recorded by Macquart as a species described by Guérin, but so far I have failed to find Guérin-Ménéville's description of this species and do not know where it was published ; Macquart says the species is from Australia. I have examined a large number of specimens of this species from the Australian region in the National Collection as well as in my own, and note that many of the males have fronts as narrow as the form *putoria*, others have fronts as wide as those of the males of the Palestine *albiceps* form noted above, so that here again we have a variable species, and it is very evident that it will be necessary to make a much more exhaustive study of all three forms to find the limits of variation as well as the characters of the external genitalia. I shall be glad to have a large number of specimens from the Australian region in order to complete this work.

I believe Robineau-Desvoidy's *Lucilia bengalensis*, from Bengal, and his *Ch. dejeanii*, from Africa, are synonyms of *albiceps*.

4. **Chrysomyia villeneuvei,** Patton.

I described this interesting and striking species in a recent number of the Indian Journal of Medical Research, pointing out that its larvae have long fleshy processes with spines on their shafts as well as their apices. It breeds in dead bodies of mammals and birds, its larvae feeding on the juices of the larvae of other necrophagous Dipterous larvae, as do the larvae of *albiceps*, but I can find no description of this species in the literature, nor are there any specimens in the National Collection. I have no doubt that it has not been recorded previously to my description. So far I have seen it only in South India, and it is essentially a wild species, never being seen to my knowledge in bazaars as would be expected.

5. **Chrysomyia combrea,** Walker.

Synonyms : *Chrysomyia* (*Musca*) *defixa*, Walker.
*Chrysomyia* (*Musca*) *pinguis*, Walker.
*Chrysomyia nigriceps*, Patton.

At the time of describing this common species of *Chrysomyia*, I was unable to get it determined, so named it *nigriceps*. But having examined Walker's types of *combrea*, *defixa* and *pinguis*, I am able to say that it is identical with these three species. It does not appear to have been described previously to Walker's *combrea*. It is mainly a temperate species and is found in all the hill stations of South India, as well as in the North, and Mr. Senior-White collected specimens in Shillong. It breeds in the dead bodies of birds and small mammals. The male has a large-lensed area on the eyes as in the male of *Chrysomyia megacephala*. I have not seen any specimens from outside the Indian area.

I have at least one other species of *Chrysomyia* from this region which I have not been able to determine, and for which I can find no description in the works of the older writers. I shall describe it on another occasion.

6. **Chrysomyia marginalis,** Wiedemann.

Synonyms : *Chrysomyia regalis*, Robineau-Desvoidy.
*Chrysomyia* (*Cosmina*) *arabica*, Robineau-Desvoidy.
*Chrysomyia* (*Somomyia*) *marginalis*, Bertolini.
*Chrysomyia* (*Paracompsomyia*) *nigripennis*, Hough.

This widely distributed African species has been recorded by Major Austen from Quetta. I have so far not seen any specimens from India other than the one from Quetta.

7. **Lucilia argyricephala,** Macquart.

Synonyms : *Lucilia* (*Musca*) *temperata*, Walker.
*Lucilia* (*Musca*) *serenissima*, Walker.
? *Lucilia* (*Musca*) *fuscina*, Walker.
*Lucilia indica*, Robineau-Desvoidy.

This widely distributed and important species was first described from the Cape. It is a well-known myiasis-producing species in Africa, its larvae having been recorded from human as well as animal tissues. In India I have had its larvae from animals, but not, so far, from man. It normally breeds in decaying animal matter and is a common fly in the bazaars of India, Burma and Ceylon.

I have examined Walker's types of *temperata*, *serenissima* and *fuscina*, and consider that they are all synonyms of *argyricephala*.

8. **Lucilia inducta,** Walker.

Synonym: *Lucilia craggii,* Patton.

This is another common Indian species, which I recently described under the name *craggii.* It is, like *Chrysomyia combrea*, mainly a hill species and is common in the north of India, and Mr. Senior-White has collected it in Shillong. It is a large blue species, and behaves much in the same way as does *Calliphora erythrocephala* in this country, coming into houses and buzzing round food. It breeds in the dead bodies of birds and small mammals.

9. **Lucilia pulchra,** Wiedemann.

Synonym: *Lucilia (Musca) phellia,* Walker.

This handsome species, one of the most beautifully coloured of all the CALLIPHORINAE known to me, is widely distributed in India. It is a larviparous species and never settles on food in the bazaars, but is for the most part found on flowers, and the female on decaying animal matter and dung of all kinds. Walker's type of his *Musca phellia*, a female, is this species. I have given a full description of it, as well as its larva and puparium, in a recent number of the Indian Journal of Medical Research.

10. **Lucilia metilia,** Walker.

Synonym: ?*Lucilia ballardii,* Patton.

The type of Walker's *Musca metilia*, from Nepal, is a male *Lucilia* in very bad preservation. I have come to the conclusion provisionally that it is the same as the species recently described by me as *Lucilia ballardii* from South India.

11. **Lucilia sericata,** Meigen.

There are two specimens, a male and female, of this well-known European semi-specic myiasis-producing fly from Parachinar, Kurram Valley, North West Frontier Province, India, in the National Collection, bred from larvae collected by Sinton from a case of human cutaneous myiasis. This is the first record of this species from the Indian Region, and I have not seen it from any other part of India.

12. **Calliphora aucta,** Walker.

This is the common Indian species of this genus, and has, I have little doubt, been mistaken for *C. erythrocephala*. It is common in the hill stations in North India, and I have recently received a number of specimens from Kashmir, collected by Dr. Baini Prashad, of the Zoological Survey of India.

This concludes my notes on the Oriental species that I have been able to study, and I need hardly say I shall be very glad to receive any specimens of CALLIPHORINAE from any part of the world, and any larvae with flies bred from them would be most valuable. I hope soon to start a series of comparative studies of some of the commoner species, describing their early stages in detail.

I have not attempted to unravel the difficult synonymy of the species of *Pyrellia* and *Pseudopyrellia*. The names of the species belonging to these genera are at present in hopeless confusion. But as soon as I have an opportunity of examining Bigot's types, as well as those of Walker, it may be possible to determine the known species accurately.

As soon as I have sufficient material from the Australian region, I hope to deal with the species of CALLIPHORINAE from that area in Part II of these notes.

# A REMARKABLE MOSQUITO, *OPIFEX FUSCUS*, HUTTON.

By David Miller, F.E.S.,

*New Zealand Government Entomologist.*

When carrying out an investigation into the mosquitos of New Zealand,* the writer found that a very common species bred in saline and semi-saline pools above high water mark along the rocky parts of the North Island coast line. For some time it was considered that this mosquito was unrecorded, but it appears that Hutton described it as a Tipulid under the name *Opifex fuscus*.† This was pointed out to me both by Mr. G. V. Hudson, of Wellington, who is in possession of Hutton's Tipulid types and had seen the illustrations here reproduced, and later on by Mr. F. W. Edwards, of the British Museum, who published a short account of the insect from material recently sent to him by Mr. Hudson.‡

So remarkable are the adult and pre-adult characters of this mosquito, that the writer considers there are sufficient grounds for the erection of a new sub-family for its reception. The following is an account of the adult and pre-adult stages with a revised outline of the generic characters.

## Subfamily Opificinae, nov.

Scales of the head and scutellum flat ; male antennae not plumose ; male palpi not quite as long as the proboscis, those of the female short ; proboscis slightly recurved ; scutellum trilobed ; cell $R_2$ of wing slightly longer than cell $M_2$.

This subfamily is apparently near the Megarhininae of Theobald, which it resembles in the flat scales of the head and scutellum ; the slightly recurved proboscis also approaches the strongly recurved form characteristic of that subfamily, to one genus of which also (*Toxorhynchites*) the short palpi of the female bear some resemblance. The relative lengths of cells $R_2$ and $M_2$, however, together with the character of the male antennae exclude this species from the Megarhininae.

## Genus **Opifex,** Hutton.

Antennae of male not plumose, the third, fourth and fifth joints each with a distinct dorsal spine arising from a pronounced basal swelling. Palpi of male clubbed at the apex, about two-thirds the length of the proboscis, which is slightly curved backwards ; neither proboscis nor palpi conspicuously haired. Antennae of female without the three spines present in the male ; palpi very short. Clypeus globular. Occiput clothed with flat scales. Legs of female normal, the front pair of the male short and stout, their claws simple but very long. Scutellum trilobed, clothed with flat scales and long bristles ; metanotum bare. Wings with base of cell $R_2$ somewhat anterior to that of cell $M_2$, the former a little longer than the latter ; cross-vein r–m anterior to origin of vein $R_{4+5}$ ; cross-vein m–cu a little more than its own length posterior to cross-vein r–m.

**Opifex fuscus,** Hutton.

♂. General colour blackish. Occiput cinereous, with a pronounced median fissure extending from the vertex to a prominence above the foramen ; uniformly clothed, except in the fissure, with white flat scales (fig. 1, *a*) ; bristles of posterior

* Miller, D., "Report on the Mosquito Investigation," pt. 1, N. Z. Dept. of Health Bull., no. 3 (1920).
† Hutton, F. W., Trans. N. Z. Inst., xxxiv, p. 188 (1902).
‡ Edwards, F. W., Bull. Ent. Res., xii, p. 73 (1921).

orbits large and black ; eyes blue-black. Antennae (fig. 1) black, with a vestiture of minute greyish hairs ; not plumose, 14-jointed, the joints for the most part narrow and not swollen ; second joint bristly ; third, fourth and fifth with a dorsal row of

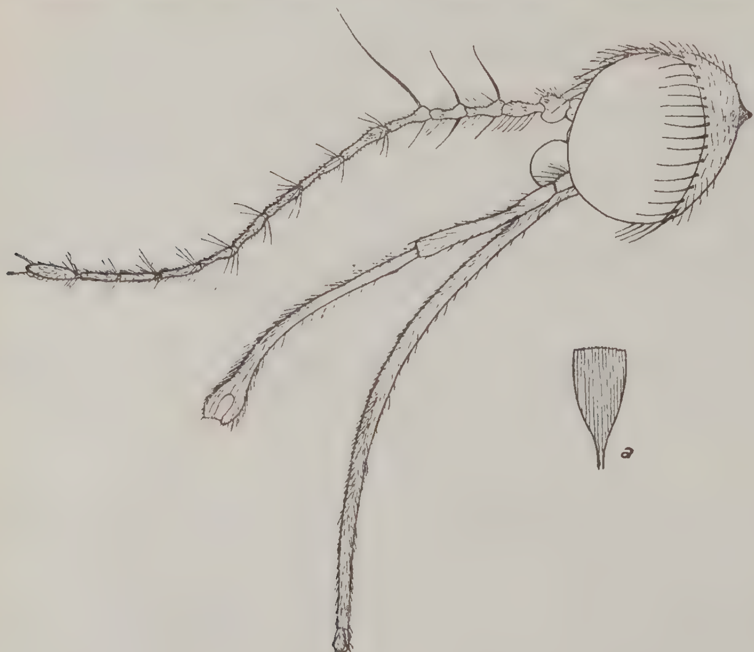


Fig. 1. Head of *Opifex fuscus*, Hutton, ♂ ; *a*, an occipital scale, enlarged.

bristle-like hairs and a basal and apical whorl of bristles, the apical ones more delicate and hair-like ; each of these three joints with a prominent dorsal swelling basally, from each of which arises a strong elongate spine, that of the fifth joint being nearly

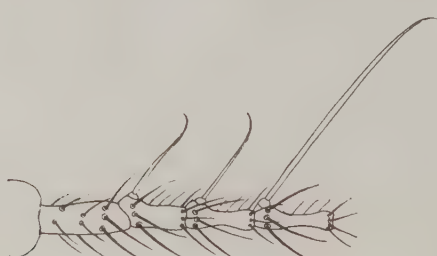

Fig. 2. Basal antennal joints of ♂.

three times as long as either of the other two (fig. 2) ; each spine appears to arise from a swelling giving the appearance of a short joint ; joints 6–14 with a basal whorl of bristle-like hairs ; apical joint elongate-oval terminating in two short hairs.

Palpi black, about two-thirds the length of the proboscis (fig. 1), clubbed at the apex, 3-jointed, with a vestiture of short, delicate greyish hairs ; first joint short and distinctly bristly ; second elongate, but not half the length of the whole ; third joint

elongated, swollen at the apex, about half the length of the whole, the apex truncated and with some bristle-like hairs and a cup-shaped depression apparently leading into an elongate glandular sac. Surface of the third joint, except for the apical knob, transversely striated by trachea-like ridges giving a serrated appearance in outline ; under a high power the ridges are seen to carry minute bristles and are not continuous but broken ; on the second joint the ridges are diagonally arranged distally, but disappear proximally, where the minute bristles are irregularly arranged ; there are no ridges on the basal joint.

Proboscis longer than the palpi (fig. 1), curved slightly backward in nearly all specimens ; black in colour and clothed with white flat scales and short greyish hairs. Labrum-epipharynx (fig. 3, 3 *a*) strongly developed. Clypeus globular, black in colour but with greyish reflections.


Fig. 3. Labrum-hypopharynx of ♂ ; *a*, apex of hypopharynx.

Thorax and scutellum black with cinereous reflections ; dorsum sparsely clothed with golden and black spindle-shaped scales and rows of black bristles ; scutellum trilobed, clothed with white flat scales and strong black bristles from each lobe ; pleurae cinereous, clothed with white flat scales ; ptero-pleurae with a tuft of golden hair-like bristles above and larger black bristles below ; mesopleurae with black bristles below ; metanotum nude, blackish brown with cinereous reflections.

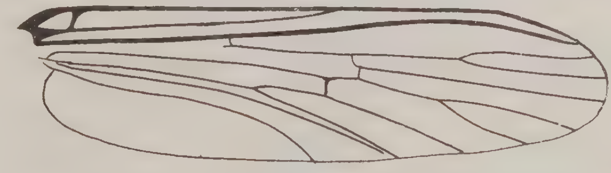

Fig. 4. Wing of *Opifex fuscus*.

Wings (fig. 4) translucent, without markings, apex blunt ; base of cell $R_2$ somewhat anterior to that of cell $M_2$, the former a little longer than the latter, which however is distinctly wider ; cross-vein r–m anterior to origin of vein $R_{4+5}$, which is geniculated ; cross-vein m–cu a little more than its own length posterior to cross-vein r–m ; veins purple to blackish brown ; the scales long and linear, among which are shorter and rather broader ones. Halteres with black globular heads and white flat scales, the stalks yellow to golden.

Anterior legs (fig. 5) stout and very much shorter than the others ; brownish black, clothed with short closely-set black bristles and flat greyish scales, becoming white on proximal part of the femora, which have a proximal row of three black bristles on upper lateral surface ; the tibiae shorter than the femora and distinctly widened ; tarsal joints swollen apically, the pro-tarsus about half the length of the whole, the following joints shortening consecutively, the onychotarsus being very short ; claws

simple, extremely long, being about one-third the length of the tarsus. Middle and posterior legs slender, the former the longer ; both deep purplish-blue with a lighter brown reflection and clothed with white scales and distinct scattered bristles ;

Fig. 5. Anterior leg of ♂.

a row of widely separated bristles distally on anterior side of the femora ; the tibiae —the posterior pair being slightly swollen apically—with a row of bristles on the posterior side and another more dorsally ; tarsi with a dorsal row of bristles ; claws simple and normal. All the femora and tibiae white at the apex.

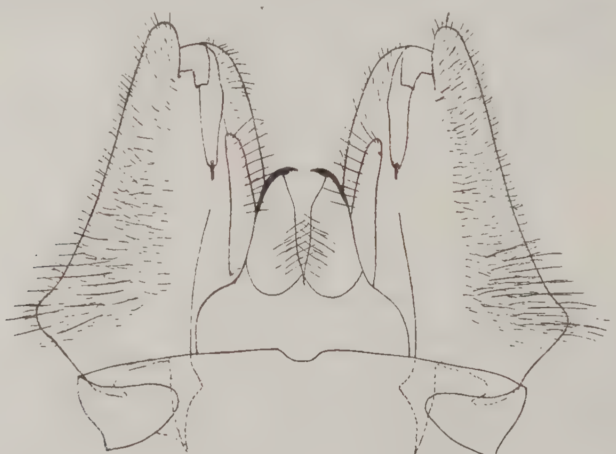

Fig. 6. Male genitalia of *Opifex fuscus.*

Abdomen shiny brownish black, clothed with short black bristles and white flat scales, the latter arranged as triangular spots at the anterior angles of each segment. Genitalia prominent, their structure shown in fig. 6.

Fig. 7. Palpus of ♀.

♀. Palpi (fig. 7) about one-fourth the length of the proboscis, 4-jointed, with a stricture near apex of fourth joint ; swollen apically, black, clothed with white scales and black bristles. The maxillae (figs. 8, 9) strongly serrated at the tip, the " feathery corrugations " referred to by Dimock being readily seen on the transparent " shaft of the maxilla." In *O. fuscus*, however, the " chitin-rod " apparently

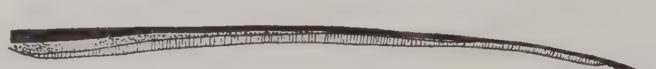

Fig. 8. Maxilla of ♀.

lies along the centre of the shaft, the two sides of which lie in a **V**-shaped position, forming a partial tube with the rod running along the fork of the fold. Antennae

Fig. 9. Apex of maxilla of ♀.

14-jointed, with no spines as in the ♂ but each joint with a whorl of sparsely set, bristle-like hairs longer on proximal joints. Front legs and claws normal. Colour as in the ♂, but the scales golden at times, and the body a deep purplish-blue in some

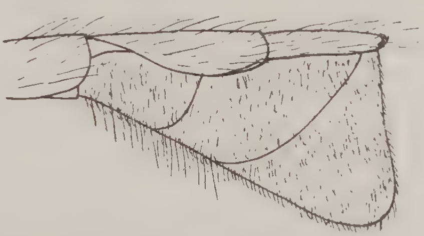

Fig. 10. Apex of abdomen of ♀ as it appears in a dried specimen.

lights. Apical sternites of abdomen swollen and descending in dried specimens (fig. 10), but normal and evenly rounded with the rest of the abdominal sternites in the living insect.

Length of ♂ and ♀, 5 mm.

**Larva.**

Larva blackish brown or sometimes greenish in colour, the segments well defined. Siphon short, twice as long as broad, with a pair of branched hair-tufts ventrally a little above the middle (fig. 11) ; siphonal pecten consisting of three short bristles

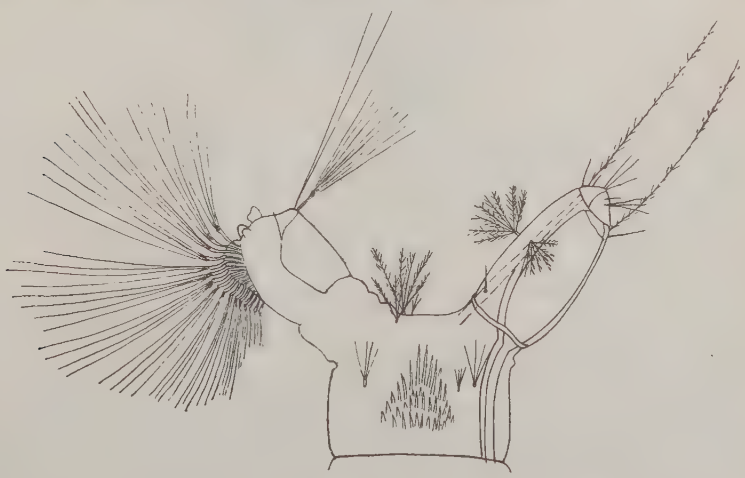

Fig. 11. Siphon and apical abdominal segments of larva of *Opifex fuscus*.

(fig. 12), on the opposite side to which, near the base of the siphon, is a single spine (fig. 11). Orifice of siphon closed externally by a pair of cup-shaped valves, from each of which arises a tuft and a single hair ; on the siphon near the orifice is a bristle-like hair and two very long and delicate branched ones ; internally the two tracheae

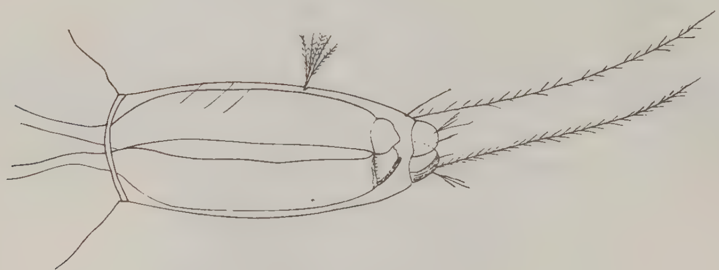

Fig. 12. Siphon of larva.

do not reach the external valves, each tracheal opening being protected by a cup-shaped valve, one being opposed to the other, so that when drawn together their rims meet and completely close the tracheae (fig. 12). Along the lower inner edge of each valve where attached to the trachea is a ridge bearing numerous short and delicate hairs (fig. 13).

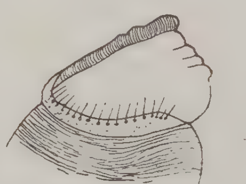

Fig. 13. An internal tracheal valve of larva.

Anal plate confined to the distal two-thirds of the anal segment and extending on each side to the median line (fig. 11) ; an inconspicuous bristle arises from anal plate on one side. Hair-tufts on dorsal angle of anal segment consisting of a pair of long straight hairs and a single tuft of somewhat shorter ones. Anal gills absent and represented by three short tubercles capable of being retracted (fig. 11). Ventral fringe well developed, consisting of several tufts of very long hairs.

Comb of eighth segment triangular, the spines strong and stout, those at the apex large and conspicuous but very short at the base ; the vestiture of this segment as in accompanying diagram (fig. 11).

Head pendulous, transversely ovate from above, narrower than the thorax, opaque ; mouth-brushes golden. Antennae apparently single-jointed, bare, except for the short terminal hairs (fig. 14). Clypeus slightly sinuated and armed with a pair of straight spines. Labrum cuneiform, its apex extending beyond the chitinous processes of the mouth-brushes ; its surface clothed with bristle-like hairs, while near its base in front of the clypeus is a small hair-tuft ; at the apex dorsally is a

clavate yellow structure clothed with hairs and with a darker central spot at its apex (fig. 14). Vestiture also shown in figure.

Fig. 14. Head of larva, dorsal aspect.

Mandibles (fig. 15) roughly rectangular, the articular surface broad, the sides converging and triangular in transverse median section: a single elongate spine on angle of outer ridge; a large claw-like and toothed appendage attached near the

Fig. 15. Mandible of larva.

outer molar angle, and from the base of the claw arise several bristle-like hairs; this appendage is apparently freely movable; on the outer molar angle is also a short toothed* appendage, while at the inner angle is a bifid hairy projection. Along one

* These appendages, in variable form, are present on the mandibles of other New Zealand mosquito larvae. They resemble to a great extent the appendages on the mandible of *Campodea* as figured by Packard in his Text-book of Entomology, p. 60, fig. 48; the movable claw resembling his prostheca, or lacinia, and the others his galea. In some other species there is a pair of elongate spines on the angle of the outer ridge agreeing with the observations of other authors.

side of the outer edge is a row of minute and strongly recurved spines, while opposite and parallel to these is a row of delicate hairs, each inserted in a small tubercle. Extending from the spine on the upper angle on to the side of the mandible is a broad ridge bearing numerous long hairs. The lower side consists of two ridges, upon each of which is a condyle for the attachment of the mandible to the cranium.


Fig. 16. Maxilla of larva, dorsal aspect; *a*, forked hair.

Maxillae (fig. 16) brownish, each, as a whole, roughly ovate but separated into two parts, apparently representing the galea and lacinia, by a median fissure extending from the apex to the base, while on the outside of the galea is a well-developed two-jointed palpus. The lacinia is shorter than the galea, and along its outer margin and upon the anterior part of the dorsal surface are numerous flat forked bristles (fig. 16, 16 *a*), which become short posteriorly and do not extend to the articulation; ventrally from the apex and almost to the articulation runs a ridge from which arise numerous long golden hairs directed outwards. The galea is shaped like the lacinia, but is truncated apically to carry a dense plume of golden brown hairs, which are as long as the whole maxilla; on each side just below the apex is a stout spine, the dorsal one arising near the outer margin and the ventral near the inner (fig. 16). Ventrally runs an indistinct ridge, near the inner margin, extending from the apex to the articulation and between this ridge and the inner margin arise innumerable golden hairs; towards the apex the surface is clothed with long delicate hairs. The palpus is two-jointed, the terminal joint being elongate and evenly rounded, though somewhat narrower apically and terminated by three short blunt teeth; the basal joint is clavate and elongate, tapering to the articulation, while dorsally near its anterior margin arises a long sinuated spine (fig. 16). Ventrally towards the base of the apical joint are numerous delicate hairs. At the articulation the lacinia is produced to a point and the galea evenly rounded. The galea, lacinia and palpus of each maxilla are united by a basal membrane, a continuation of which also attaches

them to the base of a triangular chitinous plate inserted between the cranium and the gular region ; on this plate near the attachment of the galea is a stout spine (fig. 17).

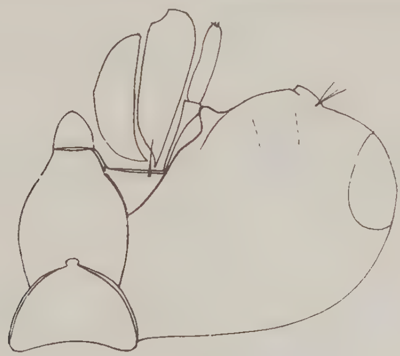

Fig. 17. One side of head of larva, ventral aspect, showing attachment of maxilla.

The vestiture of the ventral surface of the cranium is shewn in this diagram. Labium (fig. 18) triangular, its margin serrated.

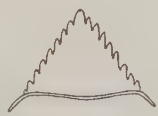

Fig. 18. Labium of larva.

Thorax much broader than the head, broadly ovate, produced on each side ; on the dorsum are two transverse sutures not extending to each side. The vestiture arranged as shown in accompanying diagrams (fig. 19).

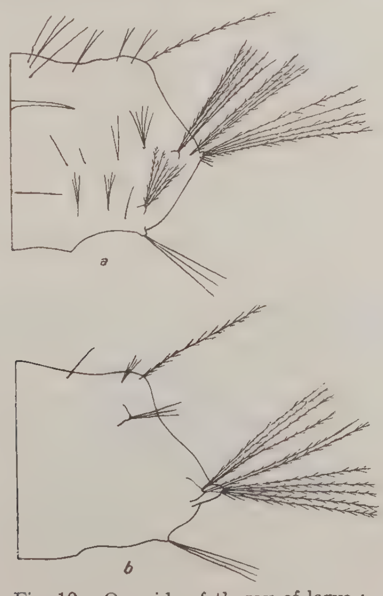


Fig. 19. One side of thorax of larva ; *a*, dorsal aspect ; *b*, ventral aspect.

The abdominal segments slightly produced laterally, except the seventh ; the lateral hair tufts longer on the anterior segments.

Length of full-grown larva 12·5 mm.

## Pupa.

Thorax with a distinct, pale brown, medio-longitudinal keel-like ridge, divided into an anterior and posterior section by a lower and broad transversely corrugated area (figs. 20, 21) ; the anterior part of the ridge is crescentic in profile and arises from

Fig. 20. Thorax of pupa, lateral aspect.

just behind the head, ending posteriorly in the transversely corrugated area, which is lower in the middle but rises at each end, where it joins the anterior and posterior portion of the median ridge. When examined from above, the corrugated area is broader anteriorly and narrows posteriorly where the median ridge arises. The posterior section of the ridge is crescentic but much lower and longer than the anterior, ending some distance before the posterior margin of the thorax ; the edge of both sections of this ridge is supported by a somewhat thickened margin. On each side of the posterior section is a lower one (figs. 21, 22) arising towards the posterior end of the corrugated area and extending almost to the posterior margin of the thorax ; the area enclosed by the two outer ridges is elongate and somewhat bottle-shaped (fig. 21). Each outer ridge is armed with short spine-like hairs along the inner side,

while more anteriorly than centrally there is a very long and straight bristle. Between these ridges and the median keel is a distinct depression. Vestiture as shown in

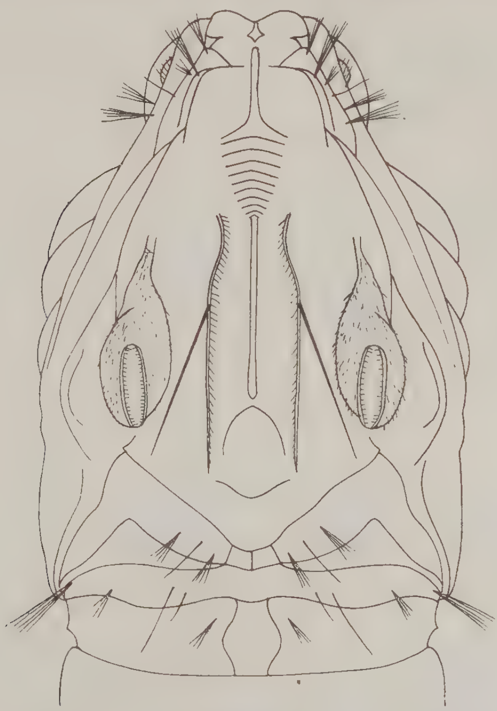

Fig. 21. Thorax of pupa, dorsal aspect.

diagram (fig. 21). Respiratory appendages situated slightly anterior to middle of the thorax, squamous, with short spines on the dorsal surface (fig. 23); the orifice

Fig. 22. Transverse section through dorsum of pupa, showing central keel and lateral ridges.

(fig. 21), when open, elongate-oval, with long delicate hairs within and short hooked bristle-like hairs along the margin.

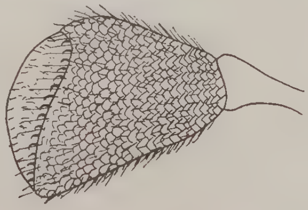

Fig. 23. Respiratory appendage of pupa.

The abdominal segments well defined. A pair of long dorsal spines, one on each side, towards the posterior margin of segments 1–6. Anal plates (fig. 24) more or

Fig. 24. Anal plates of pupa.

less circular and rather bladder-like, a conspicuous ridge supporting the outer edge of each basally; the central transverse ridge, running dorsally and ventrally, terminates in a short bristle; anal segment truncated.

## Habits.

*Opifex fuscus* is restricted to the rocky coast line and breeds in the semi-saline pools containing water left by high tides. The winter is passed as larvae and pupae, considerable numbers of the adults emerging in the early spring.

The larvae are carnivorous and cannibalistic, but also "browse" amongst the sand and accumulations on the bottom of the pools; they are able to remain submerged for lengthy periods when feeding, and occasionally come to the surface where they remain for a moment before returning to the bottom of the pool, although at other times they hang suspended from or beneath the surface. Masses of the pupae and larvae are often to be seen resting, suspended and practically motionless for long periods, well beneath the surface of the water. Large quantities of sand pass through the intestines and are voided as cylindrical pellets. The larvae will be frequently noticed to double up and draw the hairs of the anal segment through the mouth appendages or clean the orifice of the siphon. They also comb out the mouth-brushes on the comb of the eighth segment. The pupae in swimming propel themselves forward by a backward flip of the caudal appendages, at the same time turning the dorsum of the thorax over in the direction in which they desire to go.

Large numbers of the adults rest on the surface of the pools, over which they are capable of moving with considerable rapidity, aided by the small hairs along the underside of the tarsi. The whole tarsus is not applied to the water, the apical joints being held upwards from the surface. The mosquito is readily able to rise on the wing, but when at rest on the water the body is carried at a slope posteriorly, the head being in a slightly higher plane than the apex of the abdomen, while the proboscis projects forward parallel to the water-surface.

Professor H. B. Kirk, of Victoria College, Wellington, who is preparing an account of the habits of this mosquito, finds that the eggs are black and laid singly upon the rocks, against which they are inconspicuous on account of their colour.

## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st January and 31st March 1922, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Dr. G. Arnold :—14 Diptera, 54 Coleoptera, 39 Rhynchota, and 6 Orthoptera ; from Rhodesia.

Mr. E. Ballard, Government Entomologist :—24 Coccinellidae, 1 species of Aphididae, 8 other Rhynchota, and 295 Orthoptera ; from South India.

Mr. H. W. Bedford :—100 Ants, 15 Coleoptera, 6 Lepidoptera, 27 Rhynchota, and 116 Orthoptera ; from the Sudan.

Mr. C. F. C. Beeson, Forest Zoologist :—27 Parasitic Hymenoptera ; from India.

Mr. G. E. Bodkin, Government Economic Biologist :—4 Diptera, 2 Hymenoptera, and 12 Coleoptera ; from British Guiana.

Mr. J. R. Bovell, Superintendent of Agriculture :—4 Diptera, 40 Chalcididae, 5 Lepidoptera, 1 species of Aleurodidae, 2 species of Coccidae, 22 other Rhynchota, and 9 Isoptera ; from Barbados.

Dr. H. Brauns :—40 Curculionidae ; from Cape Colony.

Mr. P. A. Buxton :—2 Siphonaptera, 26 Culicidae, 7 Psychodidae, 2 Oestrid larvae, 7 other Diptera, 2 Hymenoptera, 10 Coleoptera, 95 Lepidoptera, 1 species of Aphididae, 9 species of Coccidae, 4 other Rhynchota, 14 Orthoptera, 150 Mallophaga, 32 Snails, and 3 Fishes ; from Palestine.

Mr. G. H. Corbett :—15 Coleoptera, 34 Lepidoptera, and 4 pupa cases ; from the Federated Malay States.

Mr. E. Cresswell-George :—12 Coleoptera, 3 Rhynchota, and 6 Orthoptera ; from Nyasaland.

Mr. M. T. Dawe :—11 *Glossina*, 16 Coleoptera, and a sample of coffee beans attacked by Scolytidae ; from Portuguese West Africa.

Division of Entomology, Kenya Colony :—8 Chalcididae, 27 Coleoptera, 4 Rhynchota, and 80 Anoplura ; from Kenya Colony.

Division of Entomology, Pretoria :—36 Orthoptera ; from South Africa.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist :—576 Orthoptera ; from India.

Dr. Andrew Foy :—A number of minute Diptera ; from Nigeria.

Mr. W. W. Froggatt :—2 Diptera, 6 Hymenoptera, 47 Coleoptera, and 2 Rhynchota ; from New South Wales, Australia.

Mr. D. T. Fullaway :—53 Coleoptera ; from Hawaii.

Mr. C. C. Gowdey, Government Entomologist :—2 Tabanidae, 15 Oestrid larvae, 13 other Diptera, 50 Hymenoptera, 6 Coleoptera, 5 Lepidoptera, 2 species of Coccidae, 6 other Rhynchota, 3 Orthoptera, and 1 Dragonfly ; from Jamaica.

Mr. E. E. Green :—629 Orthoptera ; from Ceylon.

Handelsvereeniging " Amsterdam " :—3 Weevils ; from Sumatra.

Mr. G. F. Hill, Entomologist, Australian Institute of Tropical Medicine :—103 Culicidae, 6 Tabanidae, 5 *Lyperosia*, 15 Hymenoptera, 68 Coleoptera and 23 early stages, 10 species of Coccidae, 6 other Rhynchota and 6 early stages, 17 Orthoptera, 4 Spiders, and 7 Scorpions ; from North Queensland.

Dr. A. Ingram :—217 Diptera ; from the Gold Coast.

Mr. J. E. M. Mellor :—4 Diptera, 39 Coleoptera, 2 Rhynchota, and 2 Odonata; from Sudan.

Dr. B. Moiser :—4 Gryllids ; from Nigeria.

Prof. S. A. Mokrzecki :—10 Dipterous larvae, 51 Hymenoptera, and 66 Coleoptera ; from Bulgaria and Poland.

Natal Museum :—80 Orthoptera ; from South Africa.

Mr. W. H. Patterson :—2,800 Diptera, 506 Parasitic Hymenoptera, 140 Ants, 161 Coleoptera, 70 species of Coccidae, 11 other Rhynchota, and 50 Mallophaga ; from Gold Coast.

Dr. L. Péringuey, Director, South African Museum :—169 Rhynchota, and 50 Orthoptera ; from South Africa.

Mr. A. H. Ritchie, Government Entomologist :—14 Tabanidae, 25 *Dacus* larvae, 44 other Diptera, 131 Hymenoptera, 875 Coleoptera, 12 larvae and 2 pupae, 194 Lepidoptera and 10 pupa cases, 3 species of Coccidae, 20 other Rhynchota, and 7 Orthoptera ; from Tanganyika Territory.

Dr. W. Roepke :—6 Hymenoptera, 14 Lepidoptera, 2 Rhynchota, and 17 Orthoptera ; from Dutch East Indies.

Mr. W. H. Simmonds :—39 Diptera, 15 Hymenoptera, 53 Coleoptera, 6 Lepidoptera, and 12 Rhynchota ; from Fiji Islands.

Mr. H. J. Snell :—26 Culicidae, 6 Hippoboscidae, 46 other Diptera, 89 Hymenoptera, 160 Coleoptera, 21 Rhynchota, 21 Orthoptera, 4 Planipennia, and 20 Odonata ; from San Thomé.

M. Ali Shirazee :—1 species of Coccidae ; from Palestine.

Mr. R. Veitch, Colonial Sugar Refining Company, Limited :—11 Diptera, and 3 pupa cases, 159 Hymenoptera, 94 Coleoptera, 169 Lepidoptera, 6 species of Aphididae, 6 species of Coccidae, 84 other Rhynchota, and 2 Ticks ; from Fiji Islands.

Wellcome Bureau of Scientific Research :—8 Siphonaptera, 8 Culicidae, 6 *Glossina*, 5 other Diptera, 2 Hymenoptera, and 37 Coleoptera ; from various localities.

Mr. G. N. Wolcott :—134 Coleoptera ; from Porto Rico.

# THE BIONOMICS OF SOME MALAYAN ANOPHELINES.

By W. A. Lamborn,

*Medical Entomologist, Malaria Bureau, Federated Malay States.*

A long series of breeding experiments were conducted by the writer at the Malaria Bureau, F.M.S., between April 1920 and April 1921 with a view to obtaining in bred families a sufficiency of Anophelines for the purpose of study which might perhaps set at rest, once and for all, various long-vexed questions as to the validity of certain species; and for the purpose of obtaining further data than were previously available as to the bionomics of the insects.

With regard to the former object it has long been recognised, for instance, that *A. hyrcanus* exhibits a very considerable degree of variation as to leg banding, colour of scaling on the wings and size of ventral tuft, which may even be absent. A not uncommon form of this mosquito occurs with leg banding so broad that a difference of opinion has arisen as to whether an insect so characterised should not be accorded specific rank, or should be treated possibly as a geographical race or a variation. The case is the more interesting by reason of the polymorphism of the larvae of this species. A similar difficulty has arisen with regard to the relationship, if any, between *A. subpictus* var. *malayensis* (until recently called *A. rossi*, Giles, in the F.M.S.), and *A. vagus*, which until quite recently was considered as being the var. *indefinitus* of the latter species. The females of *A. aconitus* are often found to be lacking the first black palpal band, a character more pronounced than some of those which have determined the bestowal of specific rank. *A. maculatus* is recorded as showing variations; and more recently attention has been directed to the variations of *A. umbrosus*.

Such variations, apart from their great interest to the student of heredity and variation, may well have considerable practical importance; for the indeterminate status of such Anophelines may serve to explain the discrepancies in the results obtained by various workers seeking to determine the relative malaria-carrying powers of the different species, and their apparent harmlessness in one country, or in one part of it, and their notoriety in another. *A. hyrcanus*, for instance, credited in the F.M.S. (where it is so variable) with being a harmless species, is considered to be an active malaria carrier in Japan and China, in which countries, so far as the writer was able to ascertain by the examination of some hundreds of larvae and adults, far less variation exists. It may well be that the forms are distinct species, that of the north, extending sparingly to the south, being a more active carrier of malaria than the southern forms. Such breeding work, the only true test of species, is therefore essential as a preliminary to any settlement of the question of the relative malaria-carrying properties of such species.

It is hoped that the questions of taxonomy will be dealt with elsewhere by an authority on the matter, the writer feeling strongly that such points are best left to systematists to deal with, attempts by those inexperienced in this special direction, and away from ample literature, tending to make confusion worse confounded.

In the following pages it is proposed to set forth only the facts of bionomic interest ascertained, with which will be included descriptions of Anopheline ova by Dr. A. T. Stanton, who has most kindly allowed his data to be added for the purpose of making the notes as full as possible. The drawings were executed for him by Mr. R. W. Blair. It will be noted that many of the lines of investigation are sketched out rather than fully developed, and that the data given make no pretence to be exhaustive; their presentation at this time is due to the unexpected transfer of the writer to another sphere of work at the end of the year.

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**Methods of Breeding.**

At the commencement of the work there was considerable difficulty such as has been experienced by other workers, which largely explains the absence of precise data on the life-history of Anophelines. The insects oviposited in any water provided, but though all sorts of water were tried in the laboratory for rearing the larvae, indifferent success was met with, even though water in which particular larvae occurred in abundance in nature was used and changed daily. Nor were better results obtained when the bowls containing the larvae of open country species were placed in situations comparable as regards sun, wind and temperature to those in which they are found in nature. For the small-pool breeders a hay infusion, in which a fairly luxuriant culture of small round green algae from such breeding-places had been obtained, yielded rather better results than were previously obtained for *A. vagus* and *A. subpictus*, and a few imagos of *A. maculatus* and *A. karwari* were obtained from the egg, the larvae feeding up on a species of *Spirogyra*. For certain species—*A. aconitus* and *A. maculatus*—gently-running water containing filamentous algae, such as are not readily washed away, was tried, and, at Dr. Hacker's suggestion, aeration of the alga-containing water was effected by means of a siphon. These devices were all to little purpose, so far as getting families of Anophelines sufficiently numerous for generalisation was concerned.

Stagnant and polluted water, containing a rich and almost pure culture of a *Euglena* (determined by Dr. Stanton as probably *E. viridis*) was then tried, and, as has been described elsewhere,* on this unpromising medium were bred from egg to imago considerable families of all the open-country Anophelines: *A. hyrcanus*, Pall., *A. barbirostris*, Wulp, *A. maculatus*, Theo., *A. karwari*, James, *A. vagus*, Dön., *A. subpictus* var. *malayensis*, Hacker, *A. ludlowi*, Theo., *A. aconitus*, Dön., *A. kochi*, Dön., *A. fuliginosus*, Giles, and *A. tessellatus*, Theo. No success at all was met with in regard to *A. umbrosus*, and ova of *A. leucosphyrus* and *A. albotaeniatus* var. *montanus*, Stanton & Hacker, were not obtained, though young larvae of the former were readily bred to maturity on the medium.

The interpretation of the success met with in the use of this medium is possibly provided by the following paragraphs (from "Comparative Anatomy of Animals," i, 1909, by Dr. G. C. Bourne), though it is difficult to reconcile the apparent welfare of the "clean breeders" with their entire absence from such polluted water in nature, unless it is that the oxygen set free in abundance renders the products of decomposition harmless by oxidation immediately they are liberated.

"One of the most striking characteristics of *Euglena* is its green colour. . . . The green tint is due to the number of circular or oval discs known as chromatophors. . . . The green colour of the chromatophors is due to chlorophyll. . . . Just as green plants are able, through the agency of their chlorophyll corpuscles, to decompose the carbonic acid in the air, setting free oxygen and combining the carbon with water to form starch, so *Euglena* is able to decompose carbonic acid. . . . When *Euglenae* are kept in a vessel in bright sunlight bubbles are abundantly formed in the water in which they are contained, and these bubbles, if collected, can be shown to consist of oxygen." (p. 190.)

"It has been observed that *Euglena* will live and apparently flourish in complete darkness for as long as 39 days."

**The Reproductive Capacity of Anophelines.**

The question is one of no little importance in connection with antimosquito measures. The ova laid by captive females were counted under a low magnification, and though very small errors in enumeration may have occurred by reason of the difficulty of the task, the data afforded as to each species are certainly correct within small limits. But the reproductive capacity of the insects, ample though it appears by the data, has probably been far underestimated, partly owing to the uncertainty

* Bull. Ent. Res., xiii, pt. 1, p. 11, May 1922.

as to previous acts of oviposition on the part of the captured females, and partly by reason of their battered condition towards the end of long confinement, whereby the oviposition of more batches of ova may well have been prejudiced. The first of these difficulties, at all events, the writer saw no means of overcoming, since pairing between the insects in captivity will not take place, probably because the males are unable to execute the complicated dances which precede coupling. The following are the data :—

*Anopheles hyrcanus.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 49 | 108 | 29 | 21 | — | 135 | — | 36 | 15 | 67 | — | 105 |
| — | 21 | 3 | 188 | — | 21 | 124 | 48 | 75 | — | — | 70 |
| — | 45 | 5 | — | — | — | 118 | — | 117 | — | — | — |
| — | — | — | — | — | — | — | — | 107 | — | — | — |
| — | — | — | — | — | — | — | — | 36 | — | — | — |
| — | — | — | — | — | — | — | — | 52 | — | — | — |

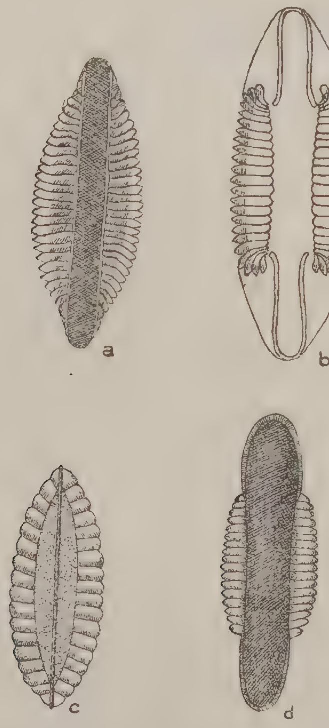



Fig. 1. Eggs of *Anopheles*: *a*, *A. hyrcanus*, Pall.; *b*, *A. maculatus*, Theo.; *c*, *A. aconitus*, Dön.; *d*, *A. fuliginosus*, Giles.

The maximum number of ova obtained from a single parent was therefore 188, and the average number from each parent, based on the data from 24, works out at 66. The following is a description of the ovum (fig. 1, *a*) :—" Length 0·56 mm., breadth 0·20 mm.; the upper surface is broad, 0·06 mm.; the floats are broad and cover three-quarters of the length of the ovum. Each float has thirty-two corrugations and these nearly touch the frill. The membrane on the lower surface has a reticulated pattern" (Stanton).

*A. hyrcanus* var. *paeditaeniatus.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| — | 90 | — | — | — | — | — | 55 | — | — | 147 | 40 |
| — | 10 | — | — | — | — | — | — | — | — | 22 | — |
| — | 13 | — | — | — | — | — | — | — | — | — | — |

The average number of ova for each parent, based on the data from 7, works out at 53, the maximum obtained from a single parent being 147.

*Anopheles barbirostris.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| — | 10 | 85 | — | — | — | 31 | 50 | 159 | — | 121 | 72 |
| — | 16 | 86 | — | — | — | 20 | 293 | — | — | 98 | 173 |
| — | 10 | 125 | — | — | — | — | 56 | — | — | 115 | — |
| — | 24 | — | — | — | — | — | 56 | — | — | — | — |
| — | 88 | — | — | — | — | — | — | — | — | — | — |

The maximum number of ova obtained from a single parent was 293, the average, based on the data from 20, working out at 69.

Dr. Stanton states that the ovum does not differ from that of *A. hyrcanus.*

*Anopheles maculatus.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| — | 18 | 143 | 34 | 42 | — | 56 | 100 | 80 | 20 | — | — |
| — | — | — | 37 | 30 | — | 128 | 123 | 20 | 22 | — | — |
| — | — | — | 95 | — | — | 71 | 16 | 72 | 56 | — | — |
| — | — | — | — | — | — | 64 | — | 72 | — | — | — |
| — | — | — | — | — | — | 30 | — | 300 | — | — | — |
| — | — | — | — | — | — | 12 | — | 24 | — | — | — |
| — | — | — | — | — | — | 81 | — | 70 | — | — | — |
| — | — | — | — | — | — | 81 | — | 17 | — | — | — |
| — | — | — | — | — | — | 36 | — | 15 | — | — | — |
| — | — | — | — | — | — | — | — | 68 | — | — | — |

The maximum number of ova obtained from a single parent was 300, and the average, based on the data from 32 parents, works out at 63. The following is a description of the ovum (fig. 1, *b*) :—" The ovum is 0·46 mm. long and 0·14 mm. broad. The upper surface is broad, and the floats touch the margin ; the narrow striated frill around the margin of the upper surface is interrupted by the floats " (Stanton).

*Anopheles karwari.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| — | 10 | 54 | — | — | — | 51 | — | 97 | — | — | — |

The maximum number of ova obtained from a single parent, therefore, was 97, and the average, based on the data from 4, works out at 53.

The ovum is precisely similar to that of *A. maculatus.*

*Anopheles vagus.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 26 | 26 | 75 | 5 | 211 | 96 | 5 | 146 | 131 | 163 | 100 |
| 63 | 42 | 69 | 66 | 5 | 86 | 56 | 35 | 98 | 115 | 109 | — |
| — | 45 | 9 | 67 | 62 | 14 | 135 | 72 | 78 | — | 20 | — |
| — | 30 | 138 | 172 | 31 | 127 | 121 | 114 | 35 | — | 176 | — |
| — | 29 | 106 | 248 | 109 | 188 | 170 | — | 59 | — | 45 | — |
| — | 25 | 20 | 32 | 112 | 50 | — | — | — | — | 60 | — |
| — | 126 | 138 | 86 | 132 | 51 | — | — | — | — | 95 | — |
| — | 56 | 110 | 28 | 87 | 196 | — | — | — | — | 126 | — |
| — | 63 | 20 | 21 | 51 | 73 | — | — | — | — | 48 | — |
| — | 152 | 8 | 170 | 58 | 155 | — | — | — | — | — | — |
| — | — | 69 | 144 | 34 | 134 | — | — | — | — | — | — |
| — | — | 92 | 34 | 184 | 149 | — | — | — | — | — | — |
| — | — | — | 142 | 98 | 75 | — | — | — | — | — | — |
| — | — | — | 61 | 172 | 25 | — | — | — | — | — | — |
| — | — | — | 143 | 151 | 171 | — | — | — | — | — | — |
| — | — | — | 13 | 42 | 167 | — | — | — | — | — | — |
| — | — | — | 36 | 223 | 146 | — | — | — | — | — | — |
| — | — | — | 27 | 56 | 148 | — | — | — | — | — | — |
| — | — | — | 156 | 82 | — | — | — | — | — | — | — |
| — | — | — | 66 | 166 | — | — | — | — | — | — | — |
| — | — | — | 5 | 211 | — | — | — | — | — | — | — |
| — | — | — | 143 | 90 | — | — | — | — | — | — | — |
| — | — | — | 156 | 173 | — | — | — | — | — | — | — |

The maximum number of ova obtained from a single parent was 273, and the average number, based on the data obtained from 114, works out at 89.

Dr. Stanton thus describes the ovum of this species :—" Length 0·54 mm., breadth 0·20 mm. The upper surface is broad and the frill continuous around the whole of its margin ; the floats, which are oblong, do not quite touch the margin and occupy three-fifths of the length of the ovum ; the corrugations number 25 ; the membrane covering the lower surface is reticulated."

*Anopheles subpictus* var. *malayensis.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | — | 88 | 87 | — | — | — |
| — | — | — | — | — | — | — | 62 | 79 | — | — | — |
| — | — | — | — | — | — | — | 10 | 114 | — | — | — |
| — | — | — | — | — | — | — | 34 | 82 | — | — | — |
| — | — | — | — | — | — | — | 114 | 52 | — | — | — |
| — | — | — | — | — | — | — | 68 | — | — | — | — |
| — | — | — | — | — | — | — | 32 | — | — | — | — |

The average number of ova for each parent, based on the data from 12, works out at 68, the maximum number from a single parent having been 114.

*Anopheles ludlowi.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | 120 | 63 | 28 | — | — | — |
| — | — | — | — | — | — | 50 | — | — | — | — | — |

The average number of ova for each parent, based on data from 4, works out at 65, the maximum number from a single parent having been 120.

*Anopheles aconitus.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 61 | 23 | 79 | 72 | 67 | 65 | 56 | 80 | 81 | — | 36 |
| 79 | 74 | 104 | — | — | 56 | 51 | 52 | 91 | 48 | — | 60 |
| 70 | 37 | 43 | — | — | 30 | 6 | 81 | 62 | — | — | 76 |
| — | 40 | 3 | — | — | — | 93 | — | 31 | — | — | 22 |
| — | — | 8 | — | — | — | 59 | — | 47 | — | — | 72 |
| — | — | 64 | — | — | — | 90 | — | 101 | — | — | 59 |
| — | — | — | — | — | — | 92 | — | 50 | — | — | 47 |
| — | — | — | — | — | — | 24 | — | — | — | — | 70 |
| — | — | — | — | — | — | 7 | — | — | — | — | 83 |
| — | — | — | — | — | — | 79 | — | — | — | — | — |
| — | — | — | — | — | — | 3 | — | — | — | — | — |
| — | — | — | — | — | — | 4 | — | — | — | — | — |
| — | — | — | — | — | — | 46 | — | — | — | — | — |
| — | — | — | — | — | — | 58 | — | — | — | — | — |
| — | — | — | — | — | — | 75 | — | — | — | — | — |
| — | — | — | — | — | — | 117 | — | — | — | — | — |
| — | — | — | — | — | — | 72 | — | — | — | — | — |
| — | — | — | — | — | — | 61 | — | — | — | — | — |
| — | — | — | — | — | — | 5 | — | — | — | — | — |
| — | — | — | — | — | — | 50 | — | — | — | — | — |
| — | — | — | — | — | — | 98 | — | — | — | — | — |
| — | — | — | — | — | — | 73 | — | — | — | — | — |
| — | — | — | — | — | — | 106 | — | — | — | — | — |

The average number of ova for each parent, based on data from 62, works out at 38, the maximum from a single parent having been 117.

Description of the ova of this species (fig. 1, *c*) :—" Length 0·40 mm., breadth 0·16 mm, ; the upper surface is extremely narrow and the frill is continuous around its margin " (Stanton).

*Anopheles kochi.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| — | 30 | — | — | — | — | 110 | — | 38 | 41 | — | 85 |

The average number of ova, based on data from 5 parents, works out at 40, the maximum number from 1 parent having been 110.

Dr. Stanton thus describes the egg :—" The ovum is 0·45 mm. long and 0·16 mm. broad. The upper surface is narrow, and the floats do not touch its margin ; the narrow striated frill is continuous around the whole of the margin of the upper surface. The floats are oblong in shape and extend over the middle two-thirds of the length of the ovum ; each float has about 20 corrugations. The thin membrane which covers the whole of the lower surface of the ovum and part of its upper surface has a reticulated pattern."

*Anopheles fuliginosus.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| — | 73 | 61 | — | — | 95 | — | — | — | 31 | 66 | 75 |
| — | 28 | — | — | — | 79 | — | — | — | 53 | — | — |
| — | — | — | — | — | — | — | — | — | 38 | — | — |
| — | — | — | — | — | — | — | — | — | 46 | — | — |

The average number of ova, based on data from 11 parents, works out at 58, the maximum from a single parent having been 95.

Dr. Stanton thus describes the ovum (fig. 1, *d*) :—" Length 0·56 mm., breadth 0·20 mm. Frill not continuous ; it is broad until it meets the floats, where it becomes narrow and is interrupted. Each float has 20 corrugations and covers the middle half of the length of the ovum. The upper surface is broad ; the lower surface is covered by a membrane which is without pattern."

*Anopheles tessellatus.*

The months of oviposition and the number of ova secured were :—

| April 1920. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. 1921. | Feb. | March. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| — | 33 | — | — | — | — | 49 | 20 | 25 | — | — | — |
| — | — | — | — | — | — | 28 | 38 | — | — | — | — |
| — | — | — | — | — | — | 28 | — | — | — | — | — |
| — | — | — | — | — | — | 15 | — | — | — | — | — |

The average number of ova, based on data from 8 parents, works out at 29, the maximum number having been 49.

Dr. Stanton finds that the ovum does not differ from that of *A. kochi*.

The ova referred to were laid in one batch, and though several bowls of similar water were often provided, almost always in one only. Exceptions were noted occasionally with *A. hyrcanus* and repeatedly with *A. tessellatus*, which usually laid a few ova day by day for five or six days. In only two instances were second large batches of ova obtained: one *A. hyrcanus* laid a batch of 45 ova during the night of 21st October and a second batch of 79 on the following night; and one *A. vagus* laid a batch of 93 ova during the night of 3rd August and a second batch of 180 ova in the course of the following afternoon.

Infection of Anophelines with the malaria parasite seemed to have no adverse influence on oviposition. An *A. maculatus*, which on dissection later showed eight zygotes in its stomach and sporozoites in all the lobes of the salivary glands, afforded a large batch of ova from which as many as 78 offspring were bred up. This observation was confirmed by experiment with 21 other females of this species, all of which, though infected, afforded ova that duly hatched out.

The tendency of the ova to drift together by capillary attraction as described for British species, and to form triangles, diamonds and other geometrical figures, was marked in the case of all species except *A. tessellatus*.

It has already been remarked that the ova when first laid are white. It was by no means unusual, especially with *A. aconitus*, to find a large percentage of a batch, still white, sunk at the bottom of the water, their floats unexpanded; and parti-coloured ova floating among black ones. For instance, of 65 ova laid by an *A. aconitus* 40 were black in colour and floated, and 25 white had sunk to the bottom of the bowl. None of either batch hatched. Such white ova as had sunk were found to have their floats unexpanded. But even brown and black ova, with floats unexpanded, were found to have sunk. This was especially the case with those of *A. tessellatus*. Thus 28 ova, normal in appearance except as to floats, and in another instance 88 similar ova, were found at the bottom of a basin of water. Sometimes floating ova never assumed their proper colour and failed to hatch. This was the case, for instance, with 30 white and 50 brown ova laid by an *A. fuliginosus* on 25th September, and with 46 brown ova laid by an *A. aconitus* on 19th October, and with 108 brown ova laid by an *A. hyrcanus* on 26th October; and such cases were numerous. Whole batches of ova, entirely normal in appearance and floating on water, sometimes failed to hatch. This was noted quite frequently with those of *A. umbrosus*, from females taken in Kuala Lumpur. Batches of these ova were sometimes kept for weeks on the assumption that incubation may be delayed. It was then thought that the medium on which they were placed might be unsuitable, but none hatched when they were transferred shortly after being laid to rainwater and to water from a natural breeding-place. It is not known whether the act of coitus in Anophelines is related, as concerns the female, to a meal of blood. If it takes place subsequent to such a meal the failure of the ova of *A. umbrosus* to hatch is explicable on the assumption that the virgin females had been compelled to leave their haunts, known to be remote from the town, in search of a meal, and had so escaped the attentions of males subsequent to it. Infertility of the ova as a cause of failure to hatch is suggested by a case in which 112 ova laid by an *A. vagus* on 5th August all duly afforded larvae, whereas of a second batch of 107 ova (39 black and 68 white) none hatched.

The ova were not always deposited on water. For instance, an *A. karwari*, enclosed in a dry tube plugged with cotton wool, was observed in the middle of the morning to be ejecting to a distance white ova, which blackened only on transfer to water, hatching in due course. An *A. barbirostris* deposited in a heap in a dry tube ova estimated at 56; these were floated off on water, becoming black two hours later, and all eventually hatched. Another *A. barbirostris*, kept in a glass tube for four days,

deposited on the fourth, in the water of condensation, a very considerable mass of ova in which incubation must have proceeded, for larvae hatched within 12 hours of their transfer to water. An *A. umbrosus* deposited about 40 ova in a dry tube, a few of which hatched in due course, having been placed on water.

It was frequently found, especially with the heavy, long-legged *Myzorhynchus* species, that unless supports, in the way of a few dead leaves, were provided, they were unable to rise from the water, and, becoming more and more involved in the surface film, eventually drowned. Ova were occasionally deposited on such leaves. Thus an *A. barbirostris* laid 58 ova on one floating leaf, and eight on another; an *A. hyrcanus* var. *paeditaeniatus* laid a batch of 36 ova on a leaf, rotting and mildewy; an *A. subpictus* var. *malayensis* laid a batch of about 88 ova on another leaf.

An interesting point arose as to whether the newly hatched larvae in such cases reached the water. All did so. In the case of the *A. paeditaeniatus* referred to, the ova on the leaf were about half an inch on all sides from the water; and the young larvae were found in the water on all sides of the leaf.

It was impossible at that time to take steps to ascertain if the ova are ever so deposited in nature, but on the assumption that this may be the case, the following experiment was devised with a view to enquiry whether newly hatched larvae have any special instinct for finding their way to water. Batches of ova, about to hatch, were transferred to a strip of blotting paper on a glass slide supported on the edge of two bowls of water so that the ends of the strip dipped into the water, which was in one bowl at a high level, in the other at a low. There being a slow current from the water at high level towards that at low level, it was thought possible that the larvae might find their way against stream, as they would do were the ova placed in nature on mud at the edge of pools. The larvae of various species were repeatedly watched wriggling by side to side movements in both directions, but more often than not there were fully as many in one bowl as in the other.

### Factors Controlling the Development of Ova.

The foregoing observation suggested an enquiry as to whether, as has been shown in the case of *Aëdes argenteus* (*Stegomyia fasciata*), the development of Anopheline ova is retarded by their being placed under unfavourable conditions, an explanation offered by Ross to account for Anopheline periodicity in India, though this is less likely to occur in a climate so moist all the year round as that of the Malay States. A distinct advantage would accrue to some of the Anophelines, especially some of the small-pool breeders, were it the case that, in the event of such a breeding-place rapidly drying up, such ova as happened to be resting on the surface could resist the effect of dessication, and could maintain their viability until such time as they again became fortunately circumstanced for hatching by the filling up of the pool. It was thought possible that such conditions, often accidentally produced in the laboratory by the gradual lowering by evaporation of the water level in basins containing ova, as a result of which the ova, which often collect through capillary attraction at the sides, become high and dry, might account for the marked inequality of size of larvae comprising one family; such ova hatching only when it became necessary to add a fresh supply of water. In a series of experiments the ova removed from the water at various stages of incubation were allowed to dry in the laboratory at ordinary temperature, and were restored to water at varying intervals, the results being noted. The following are typical of the many experiments so conducted :—

Of 36 ova laid by an *A. vagus* during the night of 18th to 19th May all were removed from the water at 8 a.m. on 19th, being then approximately under seven hours old. They were divided into two batches, (*a*) of 20, and (*b*) of 16, which were gradually dried on blotting paper in the laboratory. Twenty-four hours later batch (*a*) was restored to water, and at the end of a further period of 24 hours batch (*b*) also was restored. No hatching had taken place at the end of three days more,

and the bowl containing the ova was then placed in a sunny situation. This had no effect either; so that, unless the ova were unfertile, their removal for 24–48 hours at a very early stage of incubation, and their drying in this way, must have resulted in their death. Unfortunately no control ova were kept.

It was then thought possible that ova might retain their vitality if dried under more natural conditions—on mud. Accordingly, on 25th May, 63 ova, laid during the previous night by an *A. vagus*, were transferred at 10 a.m. to moist mud, which was then placed in a breeze to dry. By 4 p.m. all the ova were much contorted and the mud was apparently dry. After an interval of 48 hours water was gradually added so that the ova were floated off. They resumed their normal form in the course of the next 24 hours, but none hatched, though kept under observation until 10th June. A few kept on water as a control hatched in due course.

Ova at a very early stage of incubation being apparently unable to withstand even short dessication, experiments were set on foot with a view to ascertaining whether ova at a more advanced stage were more resistant. The following are typical experiments of this nature:—

About 68 ova, laid two nights previously by an *A. vagus*, were removed on 1st June at 8 a.m., and were allowed to dry in the laboratory. Twenty-four hours later 25 of these were transferred to water. On examination a day later three larvae were found to have hatched, and towards the end of the morning 11 more were found. One larva hatched out on 9th June, fully 24 hours after its fellows. The rest of the 25 were kept under observation for many days; all failed to hatch. The balance of the ova removed, totalling 43, were allowed to remain in a dry and shrivelled condition for 24 hours still longer, till 9 a.m. on 3rd June, when they were restored to water. Microscopical examination at 2 p.m. showed that all had regained their shape, and after 24 hours 4 larvae hatched out. Emergence of the others proceeded so rapidly that at 10 a.m. there were 19 larvae and at 11.40 a.m. there were 23 in all. The rest of the ova failed to hatch.

Out of a batch of 138 eggs laid during the night of the 7th June by an *A. vagus*, having been on the water about 36 hours, 103 were removed on 9th at 11.30 a.m. in five batches and were kept in the laboratory to dry. Batch (1), consisting of 9 ova, was restored to water on 11th June at 2 p.m., being then, as the result of desiccation for more than 48 hours, rather flattened though fairly full in appearance; 18 hours later 2 larvae had hatched, and 1 was seen at 8 a.m. on 12th June in the act of emergence from the eggshell; four hours later 2 more had emerged. On 13th June, at 10 a.m. another larva hatched out; 3 more were found at 8 a.m. on 15th, evidently having just hatched out, and at 2 p.m. on that day still another came out. All 9 ova, therefore, which must have been in an advanced state of incubation, withstood successfully the effects of desiccation at ordinary laboratory temperature for rather over 48 hours, the larvae emerging between 12 and 84 hours after the restoration of the ova to water.

Batch (2) of 20 ova, which had been afforded an equal period of time for incubation, was allowed to dry for 24 hours longer, about 72 hours in all, and then restored to water. The hatching was by no means so good, for 9 only, rather less than 50 per cent., emerged within a period of 24 hours, between 8 a.m. 13th and 8 a.m. 14th June.

Batch (3) of 10 ova was allowed to dry for rather over 96 hours, batch (4) of 35 ova was allowed to dry for 120 hours, and batch (5) of 29 ova for 144 hours, being then each restored to water. No hatchings at all took place, though the eggs, which were mere flattened scales, duly filled out again. The control batch of 35 ova hatched out.*

* The awkward, varying and apparently arbitrary numbers employed in these experiments are accounted for by the extreme difficulty of separating batches of tiny eggs.

The previous experiments having afforded some guide as to the length of time the ova of *A. vagus* at an advanced state of incubation are able to withstand desiccation, the following experiment was conducted in an endeavour to reproduce some greater approximation to natural conditions. On 30th June 62 ova, about seven hours old, were transferred to a thin film of water covering mud brought in a few days previously from a breeding-place of the species. Twenty-four hours later the mud was found to be hard and fissured, in which state it was allowed to remain for 48 hours more. Water was then gradually added, so as to simulate the gradual filling up of a hollow by rain ; within four hours 6 larvae were counted, and there was a gradual increase in number, until 5th July, when at 8 a.m. 36 were counted. The remainder failed to hatch.

This result, showing that some of the ova in which incubation must have been initiated are able to retain their vitality up to 72 hours when dried, was confirmed by experiments on other species than *A. vagus*. Thus, in the case of *A. barbirostris*, 88 eggs laid during the previous night were on 25th May divided into six batches, (*a*) of 12 ova, (*b*) of 8, (*c*) of 12, (*d*) of 13, (*e*) of 16, and (*f*) of 27. Batch (*a*) was left on the water to test the fertility of the ova. On 27th May 1 larva had hatched, and then unfortunately the bowl was upset so that the rest were lost. Batches (*b*), (*c*), (*d*), (*e*), and (*f*) were gradually dried ; (*b*), (*c*), and (*d*) in the laboratory, (*e*) and (*f*) in the open air. When these ova were examined 24 hours later, all were found to be much wrinkled and distorted. At 8.30 a.m. on 26th May batch (*b*), having been off the water for the greater part of 24 hours, was restored to tap water, and the following hatchings of larvae took place :—

| | | | | | |
|---|---|---|---|---|---|
| 1 larva | at about | 8 | a.m. | 27th | May. |
| 2 ,, | ,, | 9 | ,, | 28th | ,, |
| 1 ,, | ,, | 9 | ,, | 30th | ,, |
| 1 ,, | ,, | 8 | ,, | 31st | ,, |

The remaining 3 eggs failed to hatch.

Batch (*c*) was restored to water on 27th May at 8 a.m., having been off for the greater part of 48 hours, a note being then made that they were exceedingly wrinkled and distorted. By 10.30 all had recovered their normal shape, and four days later 4 larvae were found to have hatched. The remaining 8 failed to hatch.

Batches (*d*) and (*e*) placed on the water on 28th May failed to hatch, death having presumably resulted from the length of time (three days) that they had been off the water, or from the exposure to which they had been subjected.

The ova of *A. barbirostris*, therefore, even in the preliminary stages of incubation, will withstand drying for 24 hours, and a percentage even for 48 hours. A further effect would appear to be the slowing of intra-oval development, whereby larvae may take from 48 to 144 hours before emergence, the normal hatching of *barbirostris* ova, when kept under usual conditions, having been found by repeated observations to take place within about 48 hours after the eggs have been laid.

The result was confirmed with other species. Thus, 38 ova laid by an *A. fuliginosus* were divided into two batches, (*a*) of 12, (*b*) of 16. Batch (*a*) left on the water afforded on the second day 4 larvae, and 24 hours later 6 more, the remaining 2 ova failing to hatch. Batch (*b*) was removed after about 31 hours on the water, and the ova were allowed to dry in the laboratory for 48 hours. They were then restored to water ; 24 hours later 12 larvae had hatched out of the 16 ova, the rest having perished. In another experiment 18 ova were removed from the water, having been afforded the chance of incubating for about 31 hours, and 24 hours later exactly, at 11 a.m., they were restored in a wrinkled state to the water. By midday their shape was fully restored, and at 2 p.m. it was observed that 3 of the ova showed at one end a split, indicating the approaching emergence ; 2 larvae emerged shortly afterwards, when 3 more ova showed the heads of larvae presenting, though only one was successful

in making its escape, the other 2 dying *in situ*. It is therefore to be presumed that, though the ova were at an advanced state of incubation when removed, the progress of development was checked, partly or entirely, only by their removal from the water.

The viability of the various ova was found to be very considerably extended beyond these limits when they were kept in a thoroughly moist atmosphere. This is shown by the following experiments :—

Of 20 ova laid during the night of 16th June by an *A. vagus*, 8 were left as a control, and in due course all afforded larvae between 18th and 22nd June. The remaining 12 ova were removed at 4 p.m. on 17th June to a Petri dish containing moist blotting paper. The dish was unopened for 82 hours, when, at 11.30 a.m. on 21st June, all the ova seemed to be unchanged except one which had yielded a larva that was lying close beside its egg-shell. One of the ova was then placed on water and kept under observation for several days ; it failed to hatch, as did another placed on water 24 hours later. Five more of the ova still unchanged in appearance were transferred to water on 23rd June at 8 a.m. No hatching had taken place 24 hours later, but of the 4 ova still remaining in the Petri dish, almost seven days after they had been laid, 2 were seen to have their caps open. Both promptly hatched on transfer to water, and a third larva came out from one of the other two eggs later on in the same day. There then being every expectation that some of the 5 ova placed on the water on 23rd June were still alive, the bowl containing them was at 8 a.m. on 24th June put out in the open air in sunlight. At 4 p.m. 1 larva was found to have hatched, and another ovum, with its terminal cap slightly open, shortly afterwards produced a second. The bowl was placed in the sun for several days onwards, but none of the 3 remaining ova hatched.

One hundred eggs laid by an *A. vagus* during the night of 20th June were left on the water for 31 hours, and then removed to moist filter-paper enclosed in a Petri dish. The eggs, examined day by day, showed no change till the fourth day, when at 10.30 a.m. a single egg showed its cap open, and on transfer to water the larva forthwith wriggled out. Within five minutes every single egg had its cap off. On the transfer to water of 15, one by one, each produced a larva. Five of the ova transferred to water at 4 p.m. on the same day all hatched at once. With a view to testing what length of time larvae partly hatched can survive in a moist atmosphere, the remaining ova were transferred at intervals to water. On 8th June, at 8 a.m., 10 ova so transferred all hatched at once, but in the case of 18 ova transferred 24 hours later a considerable falling off in vitality was found. Three hatched almost at once ; 5 after some minutes ; the remaining 10 completely failed to hatch, but on 30th June were to be seen with the heads of the larvae presenting, as if these had died *in situ*, having insufficient energy to complete their exit. On 30th June the remainder of the ova were transferred to water. No larvae emerged forthwith, though all the ova had their caps off ; 3 only were found hatched 24 hours later, and these were feeble and perished shortly afterwards.

Of 248 ova laid by an *A. vagus* 56 were left on water as a control, and the balance, after a possible incubation period of 24 hours, were placed in a moist Petri dish. From this 56, removed at the end of 90 hours, were again transferred to water ; 6 hatched out almost at once, and by the end of 24 hours the larvae were so numerous that it was estimated that practically all must have hatched. A second batch of the same ova left in a Petri dish for 48 hours longer, *i.e.*, 138 hours in all, were then restored to water, being then 162 hours old ; 2 hatched almost at once, and the majority within five minutes. The result was equally good with a third batch of 80 ova left in the moist atmosphere 162 hours and being then 186 hours old ; 10 had their caps off ; 9 of these hatched at once on restoration to water, and it was estimated at the end of eight hours that practically all had hatched.

Sixty-nine ova laid by a female *A. fuliginosus* during the night of 5th June were divided into two batches, (*a*) of 25 as a control, and (*b*) of 44 for experimental work.

Most of (*a*) hatched out in due course. Of batch (*b*) 9 were removed forthwith from the water and placed in a Petri dish in fairly moist filter-paper. On examination 48 hours later it was found that all these ova had their terminal caps pushed open by the larvae, which could be seen still *in situ*, 2 indeed having their heads presenting. On being placed in water all hatched out almost at once, 2 sinking to the bottom apparently in an exhausted state, and struggling to the surface, after a few seconds, only with difficulty. The others moved freely, though with their bodies bent at first out of the straight line, as if stiffened by having been for some little time in a strained attitude. Ten minutes after removal all were in a normal attitude in the water and all thrived subsequently.

Seven other eggs from batch (*b*) were allowed to remain on water until 7th June at 11 a.m., having been afforded a chance of incubating for 36 hours. They were then removed to very wet filter-paper on a Petri dish. On examination 24 hours later all these ova were observed to have their terminal caps widely open, the larvae having therefore probably emerged and wriggled away, for none could be found. Moisture alone, not necessarily a more ample supply of water, would therefore appear to suffice for the hatching of the eggs, and, indeed, so limited an amount of moisture that in the one case the larvae, though fully developed, were unable even to emerge completely. The balance of the eggs was used for other experimental purposes.

The evidence therefore suggests that the incubation of Anopheline eggs having once reached a certain stage may be retarded or even inhibited by adverse conditions; for in no instance did hatching take place for a considerable number of hours after the restoration of the ova to water. Such a provision of nature might, indeed, have been expected, for it must often happen that eggs laid on a small pool are left high and dry before fresh rain again affords the stimulus necessary for their final development. It is hardly to be wondered at that freshly laid eggs at once subjected to such disadvantageous conditions uniformly fail to develop, for so sudden a removal at an early stage from a moist to a dry spot cannot take place in nature, the mere fact of their having been laid by the parent at a selected spot, probably even the smallest pool, having ensured the environment requisite for them to attain, before the pool has had time thoroughly to dry up, a degree of development that will enable them to retain their vitality. But as has now also been shown, the resisting powers may be very much enhanced in the presence of a certain amount of moisture, and development, though delayed, is able to proceed as surely as if the eggs had been normally laid on water. It would appear also that, though the larvae are fully developed under such circumstances and are ready to hatch, their actual emergence may be deferred without prejudice for some little time until conditions have become more favourable to them.

The larvae of *A. vagus* may be found in small, drying pools in mud, in situations thoroughly well protected both from sun and breeze, and where, as observation has shown, when there has been no rainfall the mud will take many days to dry up completely. Eggs deposited in such a place may well retain their vitality even when there is insufficient water to stimulate their development.

Investigations conducted for the purpose of ascertaining whether irregularity in hatching occurs as a normal process with eggs floating on water have shown that it sometimes does, at all events in the laboratory. A batch of ova laid in the course of a night by a female Anopheline may all hatch out almost at the same hour, or may show, under exactly similar circumstances, differences in hatching of many hours or even of days. An *A. fuliginosus* laid during the night of 22nd to 23rd May 73 ova. At 8 a.m. on 25th May 48 larvae had emerged. These were removed; 24 hours later 14 more larvae had appeared; the remaining 11 ova failed to hatch. An *A. vagus* laid 152 eggs during the night 30th to 31st May; of these 68 were used for other purposes, and 84 were kept apart under observation. The majority of these, 48, hatched on 2nd June; the remainder were left just as they were until 4th June, when, on microscopic examination, 19 were found to have hatched; 17 were unhatched, though great care had been taken that at no time were any of these eggs left high

and dry by evaporation. These 17 ova were restored forthwith to water at 11 a.m.; on examination at 11.40 on the same day 2 more larvae were found to have hatched. No further hatchings were noted until 7th June, when, at 8 a.m., another newly hatched larva was found, this being seven days after the eggs had been laid, five days after the first larvae had hatched, and three days after the two previous larvae had emerged. A day later, 8th June, at 8 a.m., still another newly hatched larva was found.

In the case of another *A. vagus*, 138 ova were laid during the night of 21st June; 100 were removed for the purposes of another experiment and 38 were studied in regard to their hatching. By 8 a.m. on 23rd June, 15 larvae had hatched; by 8 a.m. on the next day 3 more came out, and during the sixth night 2 more. There had been no change in conditions, and measures had been taken throughout to ensure that all the ova were floating.

Again, in the case of another *A. vagus*, 130 eggs were laid during the night of 7th June; 35 were left as they were, the remainder being removed for the purposes of another experiment. No hatching took place until 10th June, when between 8 a.m. and 2 p.m. 7 larvae emerged; 10 more larvae hatched out at intervals up till 17th June, no less than ten days after they had been laid.

In the case of *A. karwari*, 54 eggs laid by a captive female were found during the morning of 5th June. By the 8th of June larvae had emerged from the majority, but among 14 eggs then examined 5 were found with their shells still unbroken. These were then transferred to another bowl, and on 11th June a single larva hatched out at least 72 hours after the rest.

These phenomena of the hatching of Anophelines were found to be parallelled in *Stegomyia albopicta*. For example, a female laid on 12th May 32 ova, the bulk of which hatched out 24 hours later; six days later, on 19th May, 6 more larvae hatched out. Again, out of 10 ova of this *Stegomyia* laid on 17th August, 2 hatched within 48 hours,and 3 more at intervals of five, ten, and eleven days respectively.

Yet, on the other hand, in some batches of ova hatching may be practically simultaneous, even though the conditions may not be uniform for all the eggs of the batch. Thus, on the 24th June, of 110 ova laid by an *A. vagus* in the course of the previous night, 22 were transferred to water from a running brook in which the larvae of *A. maculatus* were commonly obtainable; 28 to an old infusion of hay; 13 to water containing much organic matter, from a fish-pond; 26 to water from a small muddy pool; and 21 to tap water. At 10 p.m. on 25th June no hatching had taken place, but on examination at 8 a.m. next morning the whole 110 were found to have emerged.

Though the nature of the inhibiting influence is obscure, it is plain from the following observation that hatching may be delayed even though development within the egg is complete. On 9th August 20 ova of *A. vagus*, kept for about 54 hours after oviposition in a moist Petri dish, were transferred to water. Fifteen hatched at once; the remaining 5, unhatched and floating on the water, were placed 24 hours later on a slide for microscopic examination; in the course of this all 5 larvae were seen to wriggle out, possibly under the stimulus of a hot breeze.

A batch of 114 larvae of *A. vagus*, found in a breeding-bowl on 29th November, were on 30th transferred to another vessel. Hatching of the majority immediately occurred.

A rather interesting small observation was that ova kept in a moist atmosphere in a closed Petri dish often did not hatch, even for days, until the lid was removed, the larvae then all popping out within a minute or two, possibly by reason of the effect of change of air on their enclosed space, or of the effect on the egg-shell of a sudden change of temperature. The occurrence formed a convenient means of enabling one to watch at will the emergence of the larvae. These came out with their

thoracic plumes pressed back towards the tail end ; their caudal tufts directed towards the head. On emergence the former extend themselves at right angles, suggesting the function of the outriggers of a catamaran, which function they probably serve ; the latter extend backwards.

**Time of Oviposition.**

This was noted in the case of all the open-country species as having been, as a rule, between 8 p.m. and 6 a.m. But there were a few exceptions. Thus an *A. vagus* that had been captured on 14th June deposited on 21st between 12 midday and 2 p.m. 106 ova. Another of the same species, taken on 14th June, laid, on 27th of the month, 69 ova between 8 and 10 a.m. ; a third, captured on 1st July, laid no less than 248 ova between 2 and 4 p.m. on 3rd July ; and, curiously enough, 4 others, out of 7 females of this species placed in captivity on 4th July with a view to obtaining eggs, oviposited on the same day, all between 8 a.m. and midday, one affording a batch of 67 ova, another 75 ova, the third 86 and the fourth 66. Another *A. vagus* laid a total of 248 ova between 2 and 4 p.m. one afternoon ; another laid a batch of 93 ova during the night of 3rd August, and was watched ovipositing in the afternoon of the following day, between 2 and 4 p.m., no fewer than 180 additional ova being the outcome. An *A. maculatus* was seen ovipositing at 10 a.m. on 12th October, 56 ova being obtained ; and another of the same species laid 73 ova at about 3 p.m. on 16th October.

**Length of Life-cycle.**

This was found to vary very considerably, even in the case of larvae bred from ova laid on the same day and kept under the same conditions, the lack of uniformity of development being so constant as to make it difficult to arrive at any precise calculation of the normal length of the cycle.

The following are typical data obtained from bred families :—

| Species. | Number of Ova. | Date of Oviposition. | First Offspring Emerged. | Length of its Life-Cycle. | Last Offspring Emerged. | Length of its Life-Cycle. | Total Offspring. |
|---|---|---|---|---|---|---|---|
| *A. vagus* .. | 146 | 4.xii.20 | 14.xii.20 | 10 days | 18.xii.20 | 14 days | 75 |
| *A. subpictus* var. *malayensis* | 114 | 6.xi.20 | 17.xi.20 | 11 days | 22.xi.20 | 16 days | 60 |
| *A. ludlowi* .. | 120 | 25.x.20 | 5.xi.20 | 10 days | 9.xi.20 | 14 days | 36 |
| *A. aconitus* .. | 91 | 11.xii.20 | 29.xii.20 | 18 days | 7.i.21 | 27 days | 61 |
| *A. hyrcanus* .. | 117 | 13.xii.20 | 24.xii.20 | 11 days | 30.xii.20 | 17 days | 81 |
| *A. hyrcanus* var. *paeditaeniatus* | 147 | 7.ii.21 | 23.ii.21 | 16 days | 2.iii.21 | 23 days | 64 |
| *A. barbirostris* | 159 | 12.xii.20 | 31.xii.20 | 19 days | 12.i.21 | 31 days | 47 |
| *A. maculatus* .. | 123 | 17.xi.20 | 29.xi.20 | 12 days | 4.xii.20 | 17 days | 43 |
| *A. karwari* .. | 97 | 15.xii.20 | 29.xii.20 | 14 days | 2.i.21 | 18 days | 47 |
| *A. fuliginosus* | 46 | 22.i.21 | 6.ii.21 | 14 days | 13.ii.21 | 21 days | 40 |
| *A. kochi* .. | 110 | 8.x.20 | 19.x.20 | 11 days | 24.x.20 | 16 days | 84 |
| *A. tessellatus* .. | ? | 27.xi.20 | 8.xii.20 | 10 days | 11.xii.20 | 13 days | 29 |

Apart from any irregularity of hatching, differences in the length of the life-cycle certainly depend, in part at all events, on inequality in the rate of growth of the larvae, even though kept under similar conditions. Thus, an *A. vagus* laid, on 14th May, 45 ova ; on 20th May the majority of the larvae were found to measure 5 mm. in length, and were considered as three-quarters grown ; but a small minority, looking as if they had only recently hatched, were barely 2 mm. in length. A second family of *A. vagus* larvae, all from ova deposited on 14th May, consisted, on the 20th of the

month, of a number of larvae varying in length from 1–3 mm. In the case of another family of this species, the ova were deposited on 11th May and the young larvae were first seen on 13th May. The family did not thrive. But on 21st May it consisted of 1 larva about 1 mm. in length, as small as if it had recently hatched; another 4 mm. in length, and thus well on the way to maturity; 1 pupa, a few hours in this stage of development; and of a male imago, just emerged.

A more striking instance of disparity in development occurred in a family bred from ova deposited during the night of 13th May by another *A. vagus*. Unfortunately no note as to the hatching of the larvae was made, but on 19th May when they were transferred to new water it was recorded that the larvae varied very considerably in size, some being barely 2 mm. in length, as if newly hatched, and others 5 mm. in length, and certainly more than three-quarters grown. By 2nd June, 7 of these had pupated and the imagos had duly emerged; the rest of the family then consisted, after 17 days, of 2 larvae, one 6 mm. in length, the other 2 mm. only. The diminutive size of the smaller larva was not due to any delay in hatching from the egg, for search was made for any unhatched ova on 21st May, when the only 4 found were removed.

The following were among the irregularities in development noted in the case of a number of *A. maculatus* families: The female parent, in one case, laid on 19th June approximately 143 ova, and two days later it was thought that all had hatched. At all events, all the larvae found on 23rd June were then transferred, one by one, to four bowls, in which, all being under similar conditions, 41 ultimately attained maturity. The first imago, a male, emerged during the night of 4th July, the life-cycle having therefore occupied 14 days. The other imagos came out at almost daily intervals right up to 29th July, the life-cycle of the last one having occupied no less than 39 days. There was, further, some evidence that the cycle might be extended over a considerably longer period; for at the end of the 39 days there were still 2 surviving larvae, one of which died during the night of 10th August, after a life lasting 50 days; the second survived a further five days. The interest of this particular observation lies, not only in the marked degree of irregularity of development, but also in its effect in having ensured the emergence of individual Anophelines of the same parentage throughout a long interval of time comprising both wet and dry seasons, the ova having been laid towards the end of a wet period.

In the case of a family bred from ova laid on 28th May by an *A. fuliginosus*, all hatched within 24 hours of each other and were kept in the same bowl. The first of the offspring, a male, emerged during the night of 8th June, the life-cycle from egg to imago having occupied 11 days. Thereafter imagos continued to emerge, one or two almost daily, up till the night of 18th June, 21 days, when the last imago, a female, came out. The life-cycle, therefore, of this female had occupied double the time of the first; and had it not been for the death of the single remaining pupa, the emergence of which was due in the night of 22nd June, the length of the cycle would, indeed, have been more than doubled.

The following case shows that the factors affecting the length of the life-cycle are both irregularity in hatching and irregularity in growth of the larvae. The ova deposited by an *A. kochi* on 10th May, and all kept in the same bowl with the water unchanged, afforded larvae which, ten days later, were found to vary from a bare 1 mm. to 5 mm. in length. On 18th May a note was made that there were 8 larvae, and on 21st 3 small additional ones were counted. The first pupa from this family was obtained on 20th May, and between then and 4th June there were 8 others, 4 of which died, and 4 yielded imagos (1 male and 3 females). On 31st May there were 2 larvae only, 1 barely 4 mm. long, the other about 6 mm. long. On 7th June there was discovered in addition a tiny larva looking as if newly hatched and unmistakably of this species by reason of the pearly patch on the thorax, which had characterised the other larvae in that bowl (a white one). One of these last 3 larvae died; the second pupated on the night of 10th June, no less than one month from the date on

which the ovum from which it sprang had been laid ; the third larva seemed then to be very little larger than when first seen.

The phenomena of the unequal hatching of Anopheline ova, and of the inequality in the rate of development of the larvae, must go far to ensure the continuance of a particular strain. Indeed, some such provision was to be looked for, since the Anophelines invariably deposit their ova in large numbers all at once. Were the offspring to emerge with equal precision the chances of the extirpation of the race either by natural enemies or as the outcome of unfavourable conditions would be enormously increased.

### Effect of Removal of Larvae and Pupae from Water.

Larvae removed from water rapidly succumbed even in a moist atmosphere, but pupae removed on blotting paper and kept in a thoroughly moist atmosphere were able to survive and complete their metamorphosis within the usual limits of time. It is noteworthy, as affording evidence of the hardihood of *Stegomyia albopicta*, that the pupae will survive for hours, even when thoroughly dry. On one occasion a pupa thrown on a dry surface in the very early morning was seen at 3 p.m. to be struggling vigorously when attacked by small ants.

### Hours of Pupation.

In the very great majority of instances pupation took place during the night, but some exceptions were met with. Thus a small family of 7 larvae of *A. vagus* all pupated, almost simultaneously, one afternoon, the pupae affording 3 males and 4 females. In a family of 42 larvae of *A. subpictus* var. *malayensis* 8 were recorded as pupating as 2 p.m., 7 at 3 p.m., and 6 between 2 and 4 p.m. In a family of 36 larvae of *A. ludlowi*, 21 pupated at about 4 p.m., 6 pupated in the morning (8 to 12), 1 at 10 a.m., 2 at noon ; and in three other families of this species there was also a high percentage of pupations in the day time. Of a family of 8 larvae of *A. karwari*, 5 pupated at 11 a.m. In a family of 20 larvae of *A. maculatus*, 1 was recorded as pupating at 9 a.m., 11 between 9 a.m. and noon, 1 at 11 a.m., 2 at 11.50 a.m., and 2 at 1 p.m. Similar data were obtained in the case of *A. hyrcanus*, *A. barbirostris*, *A. fuliginosus*, *A. kochi*, and *A. tessellatus*. In the case of *Stegomyia albopicta*, a day flier, it was the rule, rather than the exception, for pupation to take place by day.

It should be remarked that the exceptional pupations were not precipitated as the result of interference with larvae resting prior to pupation. In most species it was possible to infer some few hours beforehand the imminence of pupation by the change in appearance of the larvae ; in the *Myzomyia* group, in particular, there is a deepening of shade and an increase in the apparent density.

If at this stage the larvae were suddenly alarmed, as for instance by transfer to other water, pupation occurred instantly, the pupa scurrying away and gradually shedding the larval skin. This would seem to be the direct result of strong muscular action, the larval skin being already distended to its utmost limit.

It was rather astonishing to find that the pupal eye is at once functional. The pupae of a large number of *A. kochi*, known to be about five hours old, dived simultaneously, even when a shadow was slowly thrown on them by interposing an object between their bowl and an electric light at some little distance away. This was noted also with other species.

### Duration of Pupal Stage.

Pupae formed during one night usually afforded imagos on the morning but one following, that is to say, within 36 to 48 hours. No instances of any prolongation of the pupal period were ever observed, though the data as to thousands were recorded.

### Times of Emergence.

This also commonly took place during the night, usually before 11 p.m., but occasionally just before dusk, as is usual with other night-flying insects, the Anophelines being on the wing within two hours after emergence. But exceptions to the rule were noted. Thus, out of a total of 1,093 pupae, comprising various families of *A. vagus*, only 9 imagos emerged during daylight ; the whole of a small family represented by 3 males and 4 females, coming out during the morning at 11.50. This was not correlated with day pupation. A female *A. subpictus* var. *malayensis* was recorded as emerging at 4 p.m., the only instance in daylight out of 373. A single *A. ludlowi*, again, out of 113 was noted as emerging at 10 a.m. A single *A. karwari*, out of 93, came out at 11 a.m. Of *A. maculatus*, 16 out of 701 came out between 8 a.m. and 4 p.m. Out of 346 pupae of *A. hyrcanus*, 1 only was noted as coming out in the day time, at 11 a.m., and 1 imago emerged in the afternoon from 184 pupae kept under observation. Of *A. barbirostris*, 8 imagos only out of 377 came out in the day time ; of 111 pupae of *A. fuliginosus*, all emergences took place at night, so also with 206 pupae of *A. kochi*. In the case of *A. aconitus* 235 pupae afforded 1 imago only by day ; and out of 294 pupae of *A. tessellatus* 5 only came out by day.

The data are to be looked on as entirely accurate, for a very careful examination was invariably made of all pupae before the laboratory was shut at the close of the day's work.

### Proportions of Sexes in Bred Families.

Of *A. vagus* 49 families, some consisting of only 2 or 3 imagos, others of as many as 130, afforded 998 imagos, among which the sexes were represented in almost equal proportions—497 males and 501 females. In no single family was there marked inequality of the sexes. Twelve families of *A. subpictus* var. *malayensis* afforded 393 imagos (194 males and 199 females), the sexes being again almost equally represented in each family. Five families of *A. ludlowi* afforded 125 imagos (56 males and 69 females) ; 18 families of *A. aconitus*, a species difficult to breed, consisted of 105 males and 124 females ; 23 families of *A. maculatus* afforded 697 imagos (354 males and 343 females) ; 6 families of *A. karwari* afforded 93 imagos (41 males and 52 females) ; 11 families of *A. hyrcanus* gave a total of 339 imagos (172 males and 167 females) ; 6 families of *A. hyrcanus* var. *paeditaeniatus* gave a total of 184 imagos (91 males and 93 females), all true to parent ; 15 families of *A. barbirostris* afforded 394 imagos (199 males and 195 females) ; 6 families of *A. fuliginosus* afforded 111 imagos (62 males and 49 females) ; and 9 families of *A. kochi* afforded 205 imagos (93 males and 112 females). There was thus very nearly equality of the sexes in the families of all the species studied.

### House-frequenting Species.

Systematic captures of Anophelines were made at intervals, latterly twice weekly, throughout the year in different quarters of Kuala Lumpur—in native houses and cattle-sheds in the Malay kampong (village) near the town ; in certain coolie lines at some distance from the town ; and in servants' quarters attached to the house of a European in a residential suburb. The data are of interest as showing what are now the common house-frequenting species, and their proportions, a point of considerable importance, since some may be presumed to favour, as elsewhere, other hosts than man. They show also the proportion of the sexes, and afford further evidence as to the success of the campaign largely directed against the notorious *A. maculatus*, as a result of which its numbers are now so few as to be almost negligible. With a view to adding to the value of the data a record was kept of the actual numbers of such female Anophelines as had made a recent meal of blood, or had obtained one at no very recent date, as could be determined by inspection of the abdomen. Such a record is, of course, open to the objections that no positive evidence as to the source of the meal is presented (though when the replete Anophelines were taken in houses

presumably it was human), and that it is impossible to arrive by mere ocular inspection at any conclusions whether an Anopheline has had a meal a few days previously. The data are as follows :—

| | Native Houses and Cattle Sheds. | | | Coolie Lines. | | | Servants' Quarters. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Males. | Females. | Replete Females. | Males. | Females. | Replete Females. | Males. | Females. | Replete Females. |
| *A. vagus* .. .. | 26 | 57 | 26 | 966 | 2,419 | 2,045 | 538 | 830 | 426 |
| *A. subpictus* var. *malayensis* .. .. | — | 1 | 1 | — | 39 | 46 | — | 17 | 14 |
| *A. maculatus* .. .. | — | 2 | 2 | 7 | 7 | 7 | 6 | 6 | 9 |
| *A. karwari* .. .. | — | — | — | 1 | 1 | 1 | 5 | 16 | 19 |
| *A. hyrcanus* .. .. | 25 | 29 | 15 | 4 | 58 | 28 | 45 | 126 | 54 |
| *A. barbirostris* .. | 2 | 5 | 4 | 5 | 10 | 3 | 40 | 153 | 55 |
| *A. aconitus* .. .. | 2,149 | 1,294 | 775 | 165 | 292 | 233 | 227 | 1,626 | 1,175 |
| *A. kochi* .. .. | 29 | 7 | 2 | 29 | 7 | 14 | 29 | 7 | 2 |
| *A. fuliginosus* .. | 33 | 4 | 4 | 33 | 4 | 4 | 33 | 71 | 36 |
| *A. umbrosus* .. .. | 21 | 2 | 1 | 21 | 2 | 1 | 21 | 254 | 59 |
| *A. tessellatus* .. .. | 3 | 74 | 44 | 3 | 74 | 41 | 3 | 38 | 25 |

From the foregoing data it will be noted that there was a preponderance of *A. aconitus* in colleetions from the kampong (village), and from the servants' quarters near the house of a European, whereas in the collections from the coolie lines *A. vagus* was by far the most dominant species. This is explicable as to the kampong and coolie line collections by the proximity of breeding-places favourable to the two species. Near the former is a swamp from which were taken in the course of the year 13,091 Anopheline larvae, among which were no fewer than 6,381 larvae of *A. aconitus*; near the latter was low-lying ground under cultivation for sugar-cane and vegetables, and in the foul water between the furrows the larvae of *A. vagus* could almost always be obtained in abundance. The source of the Anophelines obtained at the house of the European was not determined as to *A. aconitus*; the other dominant species probably came mostly from a fish-pond at no great distance.

**The Habits of Larvae.**

In a previous paper ("The Nature and Functions of the Caudal Tufts of Anopheline Larvae," Bull. Ent. Res., xii, p. 91) a description was given of the caudal hooklets wherewith the larvae of Anophelines are able to attach themselves to objects. In moving water it is probable that all species may employ these hooks to an equal degree to avoid being swept away. But there is a marked difference in habit between those larvae that are more usually found in moving water (though sometimes in still water) and those invariably found in stagnant water. The former, of which *A. maculatus* and *A. karwari* may be taken as types, invariably attach themselves to the nearest object; the latter, for example *A. kochi* and *A. vagus*, do not seek supports to anything like the same extent. When bowls containing examples of each were placed side by side, it was at once noticed that, whereas every single *A. maculatus* larva rested at right angles to its support, many of the larvae of *A. vagus* floated quietly, well out towards the centre, entirely unsupported and in this approximating to various Culicid larvae, for example, *Stegomyia albopicta*, which, owing perhaps in part to their having no means of attachment, are never found in moving water.

It is a little surprising that Anopheline larvae favouring stagnant water have any development of caudal hooks. The writer, speculating as to their presence in such larvae, had concluded that they might be evidence of an alteration of breeding habit,

such species having, perhaps, bred in running water before there were large numbers of small open pools available. But Dr. J. W. Scott Macfie has suggested a more probable explanation: that such larvae may use their hooks to prevent themselves being driven before the wind.

Such differences of habit may well have important practical bearings, as is suggested by the following observation in regard to *Stegomyia*. A considerable number of larvae of *S. albopicta* were found in water that had collected in an old iron pan under shelter. On the surface of this was poured a mixture of heavy oil (Mobil-oil A) and kerosene, and a complete film being formed, the larvae all perished. A few days later the film of oil was found to be no longer complete, for the volatile constituents had evaporated, and the residual globules had run together into masses which had collected largely at the sides. In the spaces free from oil young larvae of *Stegomyia*, which must have originated from eggs most carefully disposed by the female parent, were found. These thrived and increased in size, though the fact of their ultimate pupation was not ascertained. The presence of the larvae, indicating their instinct and ability to keep free from a broken film of oil, suggests the high importance of an investigation as to the relative fate, under such conditions, of species such as *A. maculatus*, with a strong tendency to attach itself to supports (round which globules of oil in incomplete film tend to accumulate), and of species, such as *A. vagus*, which tend to dispense with supports. Correlated with this there tends to be a difference of feeding habit between such as like to attach themselves to objects and those which more often than not swim freely. The former, anchoring at one spot, would seem to trust largely to chance to send them the necessaries of life, either down current or wafted along the surface of the water by the wind. In this connection a definite tendency to collect all at one side was noticed in the case of larvae kept in bowls in the open, though its relationship to wind and to conditions of light was not investigated. The free-swimming larvae exhibit a more definite tendency to go in search of food. The larvae of *A. vagus*, for instance, were often watched repeatedly swimming slowly along the bottom moving their mouth-brushes and evidently feeding, in *Stegomyia* fashion. It is of interest that these small-pool breeders are among the more dominant varieties of Anophelines, for even so small an advantage of habit may be the factor accounting for their greater success compared with other species. The activity of the larvae of *Stegomyia* is certainly one of the factors which have resulted in the dominance of certain species. Those of *S. albopicta*, for instance, are far more active than those of any Anopheline. They are on the move constantly, either swimming at the surface and feeding on the surface material, often rotating as if the tail end was at a more or less fixed point; or groping at the bottom of water in receptacles, often of considerable depth, for food in the debris, into which they will often burrow so that their tails only can be seen. They can swim just as fish do in direct line, head first, altering their direction by a mere flick of the tail; they can rise or fall just as suits them without great effort; and, by reason of the greater flexibility of their bodies, they can wriggle violently in all directions so as to escape their enemies.

So it seems likely that the dominance among Anophelines of *A. vagus*, for instance, may be related to similar characteristics.

A surprising lack of wariness was exhibited by the young larvae of all the species of Anophelines. It was possible gradually to advance a spoon in the water and remove numbers at a time in their first and second ecdyses. But as the larvae became older, so they became more and more alert, until in the last ecdysis it was difficult to secure any, and with some species, *A. ludlowi* and *A. subpictus* var. *malayensis* in particular, almost an impossibility. The larvae in some families were more alert than in others of the same species, an indication possibly of a better state of health, and for this reason it was difficult to arrive at any definite conclusions as to the relative wariness of the different species. With *A. ludlowi* and *A. subpictus* var. *malayensis* a rapid advance towards the basins containing them was detected instantly, the larvae diving at once, so that on arrival not a single one was to be seen at the surface. All would be resting

at the bottom, usually ventral surface uppermost with the "tail" at an angle of 45 degrees to the body, an attitude often seen in dead larvae, whereby it would almost appear that they might be hoping to deceive enemies in search of them. It was noted that a family of larvae of *A. hyrcanus* var. *paeditaeniatus* were particularly wary, remaining under the turbid water so long (some for two minutes) that it would have been easy for any inexperienced passer-by to doubt their existence even in bowls. The larvae of *A. barbirostris* seemed to be less alert than these until a rather later age, but were yet quite wary in the last moult. A little experience with a family of these will probably be always remembered by the writer. There had been at first considerable difficulty in breeding the species, most of the larvae in families dying off and only a few attaining maturity. Trial with a new food material seemed to afford promise of far better results, for out of a very large family of half-grown larvae none had died for days, and all were active. It was with no small dismay, therefore, that on approaching the basins containing them, a day or two before the expected pupations, many were seen, lying at the bottom in various position of distortion and upside-down. At each previous inspection all had been quietly feeding at the surface, and it was felt that those at the bottom must be dead, for no movement at all was made. However, on an attempt to move them, the apparently dead larvae scuttled off elsewhere with great activity.

The alarm manifested by the larvae would seem to suggest that their instinct had apprised them of menace both from above and from the water itself ; indeed, the polymorphism of species (*A. hyrcanus* and *A. barbirostris* in particular) breeding by preference in large open sheets of water, affording many varied conditions of environment (to which the variations both of colour and pattern are due, in part at all events —as some experiments by the writer, as yet unpublished, have shown) would seem to suggest constant attack from above. From lack of opportunity the nature of this attack was not, unfortunately, enquired into very fully ; but Anthomyiid flies of the genus *Lispa*, described by Atkinson in Hong Kong and by the writer in Nyasaland as attacking Culicid larvae, were present often in very great abundance on the water at its edge, and may well take some toll of the Anopheline larvae. Furthermore, particular dragonflies were seen frequently stooping over the water, head down, as if at some prey on the surface. It is not beyond the powers of dragonflies to take creeping insects (the writer has repeatedly watched a particular species in Nyasaland catching ants), and so these may well be among the agents which cause the larvae of Anophelines to feel apprehension.

**Other Natural Enemies of Larvae.**

It is said that the larvae of Anophelines do not as a rule coexist in breeding-places with those of CHIRONOMIDAE. This is true of small muddy pools in the Malay States, in some of which the CHIRONOMIDAE larvae exist in enormous numbers. So far as could be ascertained their influence on the Anophelines is indirect only ; for, in basins, the Chironomids collected up all the floating algae with such assiduity, for the purpose of forming their larva cases, that the Anophelines soon became reduced to the verge of starvation. No direct attack was ever seen.

In certain ponds in which no Anopheline larvae were ever found in the course of searches made between April and July, certain predacious insects existed in great numbers, particularly the larvae of Neuroptera, which were never bred out (but were not those of dragonflies), and some BELOSTOMATIDAE, the females of which were frequently seen with masses of ova on their elytra. The Neuroptera in particular were highly predacious, devouring each other when confined in basins, even though supplied with ample other food material in the shape of Culicid larvae.

The writer has to acknowledge his obligation to the most efficient staff, trained by Dr. H. P. Hacker, the officer in charge of the Malaria Bureau, and particularly to Mr. Daniel Rajamoney and Mr. M. C. Chuen, for their untiring enthusiasm and patience in carrying out the details of the tedious breeding experiments.

# FURTHER NOTES ON THE TABANIDAE OF PALESTINE, WITH DESCRIPTIONS OF NEW SPECIES.

By Major E. E. Austen, D.S.O.

During the two years that have elapsed since the publication by the writer of a previous paper on Palestine Tabanidae,* a small amount of material belonging to this family has been received from the same country. With one exception, for the Diptera in question—which, though few in number, present several points of interest, besides including representatives of two new species—the National Collection is indebted to the kindness of either Mr. P. A. Buxton or Mr. I. Aharoni.

The types of the new species, as well as the other specimens referred to below, are in the British Museum (Natural History).

## Pangoniinae.

### Genus **Chrysops,** Meigen.

As stated by the author in his former paper (*loc. cit.*, p. 278), the only member of this genus met with by him from Deir el Belah to Haifa, during upwards of 18 months' service in Palestine in 1917–18, was *Chrysops punctifera*, Lw. Mr. Buxton is therefore heartily to be congratulated upon the discovery of the species described below.

**Chrysops buxtoni,** sp. n. (figs. 1, 2, 3).

♂ ♀.—Length, ♂ (four specimens) 8·5 to 9·4 mm., ♀ (four specimens) 7·75 to 8·75 mm.; width of head, ♂ 3·5 to 3·75 mm., ♀ 3 to just under 3·5 mm.; ♂, eyes meeting in centre of top of head for a distance of about 0·5 mm.; ♀, width of front at vertex 1·25 to just under 1·5 mm.; length of wing, ♂ 7·6 to just under 8 mm., ♀ 6·75 to 7·2 mm.

*Medium-sized, stoutly built, thick-set species, with an unusually broad head in both sexes, with abdominal markings as shown in figs. 2 and 3, and in both sexes with wing-markings as in fig. 3; legs mainly black, front tibiae at base, and middle and hind tibiae except distal extremities ochraceous–tawny.*†

*Head* in both sexes olive-buff pollinose or pale olive-buff pollinose, clothed with fine hair of similar colour, which on face and jowls of ♂ is especially dense and long; ocelligerous tubercle in ♂ black, large, swollen and prominent, thinly covered with greyish pollen, and clothed in front with fine black or blackish hair; apex of frontal triangle in same sex shining black, in certain specimens occupied by a minute ovate or elongate ovate tubercle, which sometimes has an elongate depression in its upper extremity; face and jowls in ♂ uniformly pollinose, without shining tubercles or other areas; ♀ with a more or less shining black area (roughly triangular in shape, with prominent, rounded angles) surrounding the ocelli, and in well-preserved specimens not connected with the eyes, though traces of a black transverse band uniting it to the eye on each side are sometimes visible; *frontal callus* in ♀ shining

* *Cf.* E. E. Austen, "A Contribution to Knowledge of the Tabanidae of Palestine": Bull. Ent. Res. x, pp. 277–321, figs. 1–18 (April 1920).

† For names and illustrations of colours used for descriptive purposes in the present paper see Ridgway, "Color Standards and Color Nomenclature" (Washington, D.C. Published by the Author, 1912.)

black, transversely elongate and more or less elliptical in outline, its transverse diameter from two and a half to three times the length of the other ; face in ♀ with a pair of elongate (often roughly pyriform), shining black *facial tubercles* ; jowls in same sex uniformly pollinose ; *eyes* in ♂ conspicuously transversely elongate, nearly twice as wide as deep, with area occupied by enlarged facets presenting a sharp colour-contrast to remainder (in dried specimens cinnamon-drab, drab-grey or smoke-grey, as opposed to purplish-black) ; eye-markings in ♀ resembling those exhibited by *Chrysops punctifera*, Lw., ♀,* but with the two lower spots on the inside in contact

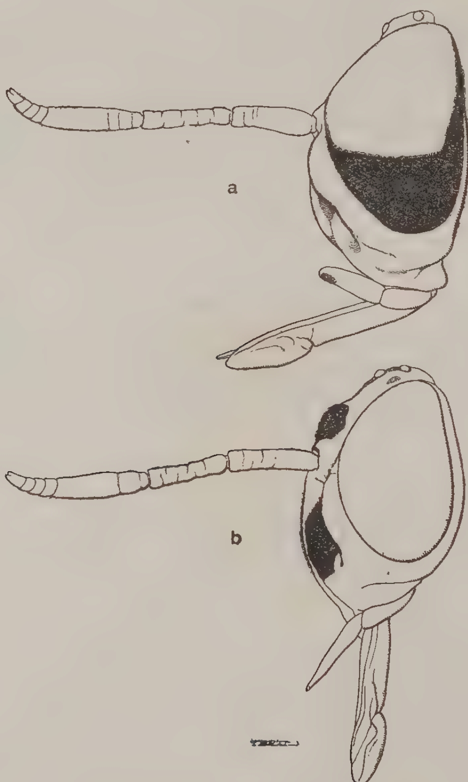



Fig. 1. Head of *Chrysops buxtoni*, Austen, in profile : *a*, ♂ ; *b*, ♀ ; ×10.

with the inner margin of the eye, and the uppermost spot not connected (at least in many cases) with the hind border ; *palpi* in ♂ clothed with hair similar in character and coloration to that on jowls, proximal segment elongate, deep neutral grey, distal segment one-third as long again as proximal segment or longer, narrowing slightly distally but not tapering to a conspicuous point, ochraceous-buff, with dark brown elongate spot on outer surface just before the tip ; proximal segment *of palpi* in ♀ neutral grey, clothed with hair like that on jowls, distal segment narrow, straight, conspicuously elongate, about two and a half times as long as proximal segment, partly dark brown or blackish-brown, partly pinkish-buff or cinnamon-buff, sparsely

* *Cf*. Austen, Bull. Ent. Res., x, pt. 3, p. 279, fig. 1 (April 1920).

clothed with minute, glistening pale yellowish hairs, and with some minute blackish hairs at extreme tip ; *antennae* black, first segment in ♀ paler (cinnamon or pinkish-cinnamon) on proximal half or two-thirds, at least on inner side, first segment in ♂ somewhat thickened at base, but not noticeably incrassate, slightly greyish pollinose, and clothed with long hair of same kind and colour as that on face, second segment in ♂ clothed with minute black hairs and rather longer than first segment, third segment in ♂ about one-half longer than second ; *antennae* in ♀ more slender than in ♂, first segment not at all incrassate, second segment approximately equal in length to first segment or rather shorter, third segment from one-third longer than, to nearly half as long again as first, latter clothed with short, glistening cream-buff hairs, mixed with black hairs above and towards distal extremity, second segment clothed with minute black hairs. *Thorax* (including scutellum) shining black above, in ♂ with a pair of faintly indicated, broad, admedian greyish stripes extending from anterior margin to region of transverse suture, in ♀ with a pair of well-defined, narrower, admedian, pale olive-grey longitudinal stripes, extending from anterior margin to prescutellar groove, where each stripe curves outwards to join corresponding lateral border, which, like anterior border and interspace between longitudinal stripes in front is light olive-grey pollinose ; pleurae and pectus olive-grey or light olive-grey pollinose in both sexes ; thorax in both sexes clothed with long, fine

Fig. 2. Abdomen of *Chrysops buxtoni*, Austen, ♂, dorsal view ; ×7.

whitish or yellowish hair, particularly dense on pleurae, but in ♀ somewhat shorter above. *Abdomen :* upper surface (*cf.* figs. 2 and 3) mainly pinkish-buff or cream-buff in ♂, mainly black in ♀ ; first (visible) tergite in ♂, except posterior angles and a deep hind border on each side equal to about one-fourth of the breadth of the segment, shining black ; second tergite in same sex with a large, shining black median spot, roughly circular in outline or irregularly quadrate with its posterior angles rounded off, resting on base, but not quite reaching hind margin, and on each side at base with a fainter (neutral grey) extension connecting it with hind margin of preceding segment ; third tergite in ♂ with a large, roughly cordate median black spot, equal in width to spot on second segment, separated by a considerable interval from hind margin, but with its forwardly directed apex closer to or actually in contact with front margin ; fourth tergite in ♂ with a median, basal black spot (most distinct when abdomen is viewed at a fairly low angle from behind), in shape resembling posterior half of spot on third segment, or sometimes looking like a pair of admedian triangles, separated by a greyish-olive, pollinose median triangle, base of which rests on hind margin ; fifth and sixth tergites in ♂ greyish-olive or pale smoke-grey pollinose, with pinkish-buff hind borders, fifth tergite, at least when viewed at a fairly low angle from behind, usually exhibiting a pair of small, admedian, black triangles, resting on front margin ; third and two following tergites in ♂, at least when viewed at a more or less low angle from behind, each exhibiting a median, forwardly directed,

greyish-olive or pale smoke-grey pollinose triangle, which in each case has its base resting on hind margin, while apex reaches anterior margin in case of triangle on fifth segment, though on fourth tergite triangle is confined to posterior two-thirds, while on third tergite triangle does not extend beyond half-way; venter in ♂ resembling dorsum, though median spots or blotches on first two (visible) sternites are fainter (neutral grey or deep neutral grey pollinose), while those on the three following sternites are transversely oblong, and last three sternites (except, in case of penultimate and antepenultimate sternites, hind borders and median transverse blotches) are iron-grey; abdomen in ♂ clothed mainly with whitish or yellowish (cream-buff or cream-coloured) hair, longer and finer on lateral borders, some of the dark spots, especially on ventral surface, covered mainly or partly with black or blackish hair; dorsum in ♀ (see fig. 3) with a cream-buff or cream-coloured transverse band (deep at each lateral extremity, but very narrow in middle, and with deeply sinuous, bilaterally


Fig. 3. *Chrysops buxtoni*, Austen, ♀; ×7.

symmetrical anterior and posterior margins) occupying hind border of first (visible) segment and anterior border of second segment; second and three following tergites in ♀ each with a median, forwardly directed, light brownish-olive pollinose triangle resting on hind margin, these triangles varying in size in different individuals; while in some cases all the triangles are small, in others the three hindmost are large, the apex in each instance almost, if not quite, reaching the hind margin of the segment in front; third and two following tergites each with a more or less distinct, light brownish-olive pollinose, elongate mark between median triangle and lateral margin on each side; sixth and seventh tergites in ♀ and hind borders of the four preceding segments light brownish-olive pollinose, sixth tergite sometimes with a pair of small, admedian black flecks on fore border; extreme lateral margins of first five (visible) tergites in ♀ smoke-grey or pale smoke-grey pollinose; venter in ♀ mainly brownish-black, moderately shining, lateral extremities of each sternite (sometimes as much as lateral thirds in case of first four visible sternites), and hind margins or hind borders of second and following sternites light greyish-olive pollinose;

abdomen in ♀ clothed on black areas with minute black hairs, otherwise clothed with short, appressed, glistening cream-buff hair. *Wings* in both sexes with blackish-brown markings as shown in fig. 3; blackish-brown costal border not extending beyond end of first longitudinal vein; basal cells, except their extreme distal extremities and a small, blackish-brown fleck at base of second basal cell, entirely clear; transverse band dying away in base of fifth posterior cell and apex of anal cell, without distinctly reaching hind margin; discal cell either entirely blackish-brown, or exhibiting a more or less well-defined, hyaline or semi-hyaline, longitudinal streak; anal cell closed shortly before (occasionally on) wing-margin. *Squamae* in both sexes light isabella-coloured, with cream-buff borders. *Halteres* blackish-brown. *Legs:* tibiae not incrassate in either sex; coxae olive-grey pollinose, clothed with whitish hair; femora entirely black, more or less greyish (neutral grey) pollinose, clothed with whitish hair, except distal halves of front pair, which are covered with black or blackish hair; proximal halves or two-thirds of middle and hind tibiae clothed with glistening Naples yellow hair, which, especially in ♂, forms a conspicuous fringe on inner and outer surfaces of hind pair, the fringe towards the distal extremities gradually changing to black hair; tibiae otherwise clothed with black hair, with exception of a few minute, glistening Naples yellow hairs at extreme base of extensor surfaces of front pair; tarsi clothed with minute black hairs, first segment of middle and hind pair ochraceous-tawny (or cinnamon-rufous) at base, tarsi otherwise black.

Zikron Jakob and Khedeira (both in coastal zone—*P. A. Buxton*).

Type of ♂ and two paratypes belonging to the same sex, Zikron Jakob, 17.v.1921; type of ♀, one ♂ and three ♀ paratypes (one of the latter taken "on horse's neck"), Khedeira, 30–31.v.1921.

The fine species just described, to associate which with the name of its discoverer affords much pleasure to the author, is allied to *Chrysops hamata*, Lw., the typical specimens of which were taken by its describer near Makri, on the south-west coast of Asia Minor. *C. buxtoni*, however, differs from the species mentioned, *inter alia*, in the smaller size of the ocellar callus in the ♀; in details concerning the abdominal markings in both sexes; and in the transverse band on the wing in both ♂ and ♀ being much more sharply defined, and by no means consisting simply of an "edging to the transverse veins," as is stated by Loew to be the case in *C. hamata*. In the latter connection it may be of interest to state that, in the case of one of the ♀ paratypes of *C. buxtoni*, while the left wing is perfectly normal, the other has the transverse band reduced to a narrow streak traversing the tips of the basal cells and the proximal extremity of the discal cell.

**Chrysops punctifera,** Lw.

For this species, which, owing to its having a sharply defined, clear "window-pane" in the discal cell, is placed by Kröber in his Group *Heterochrysops*,* the following are additional localities, etc.:—

One ♀, Zikron Jakob, 17.v.1921 (*P. A. Buxton*); one ♀, Zahlé, Lebanon, 20.v.1917, one ♂, same locality, 2.viii.1918 (*I. Aharoni*). Two ♂♂ and two ♀♀ of this species—the latter on a horse—were also taken by Mr. Buxton at Haifa, 20–28.v.1921.

## TABANINAE.

### Genus **Haematopota,** Meigen.

In the paper published by the author in 1920, it was shown that the material belonging to this genus obtained by him in Palestine seemed to represent four species, all of which were apparently new. The data referring to additional specimens of two of these species, received during the past twelve months, are recorded below.

* *Cf.* O. Kröber, "Die Chrysops-Arten der paläarctischen Region nebst den Arten der angrenzenden Gebiete": Zool. Jahrb., Abt. f. Syst., xliii, pp. 42, 50, 56, 60, Taf. 2, figs. 63–65 (1920).

**Haematopota sewelli,** Austen.

*Haematopota sewelli*, Austen, Bull. Ent. Res., x, p. 281, figs. 2, 3 (April 1920).

Two ♂ ♂, Wadi Hamam, Galilee, 7.iv.1922 (*P. A. Buxton*) ; one ♂, Nahr Rubin (coastal zone), 25.iv.1921 (*I. Aharoni*) ; eleven ♀ ♀, Khedeira (coastal zone), 30.v.1921 (*P. A. Buxton*).

**Haematopota innominata,** Austen.

*Haematopota innominata*, Austen, Bull. Ent. Res., x, p. 290, fig. 4, *c* (April 1920).

One ♀, Khedeira (coastal zone), 30.v.1921, and nine ♀ ♀, Akka (coastal zone), 10.vi.1921 (*P. A. Buxton*).

Genus **Tabanus,** Linn.

In the author's previous paper, to which reference has already been made, 16 species of *Tabanus* were included. Two additions—*T. agnitionalis*, sp. n., and *T.* (*Ochrops*) *kertészi*, Szil.—to the list of these are made in the following pages, so that the total number of species of *Tabanus* now known to occur in Palestine is raised to 18.

**Tabanus agnitionalis,** sp. n. (fig. 4).

♀.—Length (one specimen) 15·5 mm. ; width of head 5 mm. ; width of front at vertex 0·8 mm. ; length of wing 13·6 mm.

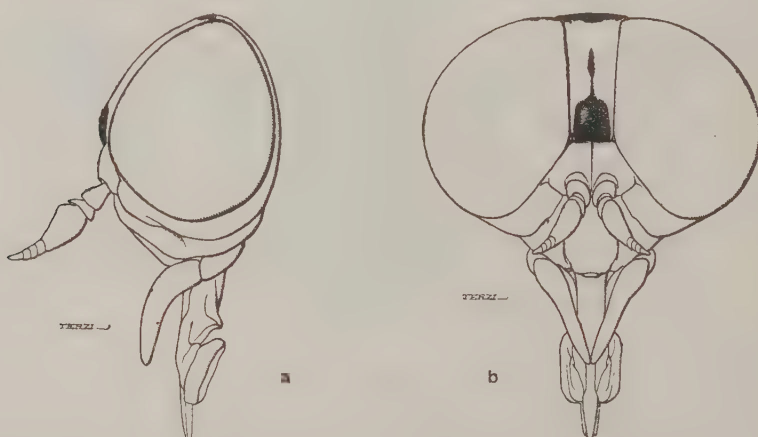


Fig. 4. Head of *Tabanus agnitionalis*, Austen, ♀ : *a*, lateral view ; *b*, viewed from in front ; × 10.

*Hairy-eyed, medium-sized species, with large, shining, cinnamon-brown lower frontal callus in ♀ ; dorsum of thorax dark neutral grey, conspicuously striped (except scutellum) with lighter grey ; dorsum of abdomen beyond first (visible) segment for most part cinnamon-buff, but having the last three segments mainly infuscated—deep greyish-olive pollinose, and a large, quadrate median blotch of same colour on each segment from second to fourth inclusive ; legs, except coxae, trochanters, extreme bases of femora and at least distal extremities of tarsi, cinnamon-coloured.*

*Head :* front in ♀ deep olive-buff pollinose (slightly darker—light brownish-olive—in region of upper callus), densely clothed above and at sides of upper portion of lower callus with short, glistening Naples yellow hair, which towards vertex becomes longer, paler and sparser ; subcallus in ♀, face, jowls and occiput smoke-grey

pollinose, clothed with olive-buff or pale olive-buff hair (ground-colour of subcallus showing a trace of cinnamon above base of each antenna, at least in case of type), posterior orbits pale olive-buff, of moderate breadth and conspicuous, fringed posteriorly above with short, but noticeable, hair of same colour as that clothing remainder of occiput ; *front* in ♀ of moderate width, narrowing slightly from above downwards, about four times as long as its breadth at lower end, with *a well-marked ocellar tubercle surrounded by a shining, cinnamon-brown, roughly circular or oval spot*, connected with each eye, at and just in advance of upper inner angle of latter, by a short, narrow, transverse extension of same colour ; lower *frontal callus* in ♀ narrowly separated from eye on each side, its lower margin straight and on a level with lower, inner angles of eyes, its upper extremity somewhat narrower and with its angles rounded off, upper frontal callus represented by a narrow, black, longitudinal, median streak on upper third of lower half of front, not connected with lower frontal callus, though type shows indications that it would probably be so connected in a more denuded specimen ; *eyes* densely clothed, at least anteriorly above, with minute, pale whitish hairs, and bearing (in ♀ sex) three dark purple, transverse bands ; *palpi* cinnamon-coloured, proximal segment clothed with long hair of same colour (olive-buff) as that on jowls and basioccipital region of head, distal segment in ♀ narrow and elongate, not swollen at base and afterwards bluntly tapering, clothed on outer surface with minute, appressed, glistening ivory yellow hairs ; *antennae* orange-cinnamon, annulate portion of third segment more or less blackish-brown (terminal annulus entirely blackish-brown), upper margin of expanded portion of third segment also tinged with blackish-brown near its distal extremity, first segment thinly smoke-grey pollinose, clothed externally with glistening Naples yellow hair, only moderately swollen distally, its upper distal angle (which bears some minute black hairs on its inner margin) not embracing second segment, latter clothed externally with glistening Naples yellow hair, with a few minute black hairs on its upper distal angle, which is moderately produced, expanded portion of third segment fairly deep, about one-fourth longer than annulate portion, and with a blunt angle on upper margin near base. *Thorax :* light longitudinal stripes on dorsum consisting of a narrow median stripe, two broader admedian ones, a fairly broad stripe on each side of the posterior half of the scutum, connecting the bifurcation of the transverse suture with the postalar callus, and, lastly, the lateral border on each side including humeral and postalar calli, and antealar tubercle ; each light admedian stripe curves outwards on hind margin of scutum and joins corresponding postalar callus ; coloration of light dorsal stripes varying from smoke-grey to light greyish-olive (median stripe mainly greyish olive) ; dorsum, including scutellum, clothed with short, fine Naples yellow hair ; pleurae and pectus smoke-grey pollinose, clothed with whitish, yellowish-white or yellowish hair. *Abdomen :* first (visible) tergite (except posterior angles, which are cinnamon-buff) greyish-olive pollinose ; median blotch on each tergite from second to fourth inclusive, commencing at base, but stopping short before reaching hind margin, though the fact that it does so may be concealed by greyish-olive pollen and the hairy covering ; lateral borders and hind margins of fifth and following tergites cinnamon-buff ; third and fourth tergites each with a dusky blotch, clothed with short black hairs, on each side of its anterior border, near basal angle ; same two tergites each with a black-haired, bicuspid mark (visible only when insect is viewed from certain angles) at base of its median blotch ; in case of third (perhaps also in that of fourth) tergite the bicuspid mark is connected with the dusky basal blotch on each side by a narrow band of minute black hairs ; median blotch on second tergite with a few minute black hairs at base ; dorsum, except as stated, thickly clothed with short, appressed, glistening Naples yellow hair, beneath which is a thin covering of smoke-grey pollen, so that from certain directions the ground-colour is obscured ; venter (except hind borders of second and following sternites, which are cinnamon-buff or cream-buff) uniformly pinkish-cinnamon or light pinkish-cinnamon, without a trace of a dusky, median, longitudinal stripe, thinly covered with smoke-grey pollen, and clothed with pale hair like that on dorsum—no black hairs anywhere

visible, even on seventh sternite. *Wings* somewhat dusky (lightly tinged with sepia, and, at least in case of type, membrane adjoining majority of veins in distal halves faintly suffused with a slightly darker shade of same colour); veins for most part mummy-brown, in certain cases such as auxiliary (mediastinal), first longitudinal, and proximal portions of second, third and fifth longitudinal veins paler (ochraceous-tawny); anterior transverse vein, and basal portion of anterior branch of fifth longitudinal vein appearing darker than veins elsewhere; *stigma* ochraceous-buff, elongate, well defined and fairly conspicuous. *Squamae* drab-grey, with cream-coloured borders fringed with pale yellowish hair. *Halteres:* knobs blackish-brown, stalks paler (dark olive-brown). *Legs:* coxae and trochanters smoke-grey or mouse-grey pollinose, clothed (densely in case of front coxae) with hair similar to that on pleurae, traces of cinnamon ground-colour showing through pollinose covering in case of front coxae; extreme bases of femora, at least on underside, mouse-grey or deep mouse-grey, hind femora also with a deep mouse-grey pollinose streak extending from base a very short distance along middle of outer side, femora and tibiae clothed with glistening cream-buff hair; last three segments of front and middle tarsi (except at base), and last segment of hind tarsi blackish-brown, remaining tarsal segments tipped with dark brown; distal segments of front tarsi only moderately expanded.

Wadi Sikat (Ramleh district), 3.xi.1921 (*Colonel Fulton*, A.A.M.C., per P. A. Buxton).

*Tabanus agnitionalis*, which cannot be confused with any species included in the author's previous paper on Palestine Tabanidae,* is certainly, so far as can be judged from Macquart's brief description (Mém. Soc. roy. des Sc., de l'Agric. et des Arts de Lille, 1838, p. 298. Lille: 1838), distinct from the Arabian *T. arabicus*, Macq., with which it agrees more or less in size, in the coloration of the antennae and legs, and in the dorsum of the thorax being marked with light stripes. Macquart, however, while giving no indication that the eyes in *T. arabicus* are hairy, states that the palpi in this species are yellowish-white, and the halteres yellow.

From *Tabanus graecus*, Fabr., which *T. arabicus* is stated by Macquart to resemble, the species described above is distinguishable in the ♀ sex by its conspicuously hairy eyes, broader front and very differently shaped frontal callus, as well as by the ventral surface of the abdomen being uniformly pale (pinkish-cinnamon), instead of having a dark median blotch at the base of the second (visible) segment, and the last four scutes (except their hind margins) olivaceous-black; finally, the new species may be distinguished from *T. graecus* by the femora, except their extreme bases, being cinnamon-coloured instead of blackish mouse-grey.

**Tabanus decorus,** Lw.

One ♂, one ♀, Nahr Rubin (coastal zone), 5, 25.iv.1921 (*I. Aharoni*); one ♀, Jisr Banat Yakub, Galilee, 5.iv.1922, and one ♀, Wadi Hamam, Galilee, 7.iv.1922 (*P. A. Buxton*).

**Tabanus alexandrinus,** Wied.

*Cf.* Austen, Bull. Ent. Res., x, p. 295, and p. 298, fig. 5 (April 1920).

Two ♂♂, Rehoboth (Jaffa district), 26.iv.1916 and 26.iv.1921 (*I. Aharoni*).

**Tabanus insecutor,** Austen.

*Tabanus insecutor*, Austen, Bull. Ent. Res., x, p. 296, fig. 6 (April 1920).

One ♀, Haifa, 17.v.1921 (*P. A. Buxton*).

The type of *T. insecutor*—the only other specimen of this species hitherto obtained—was taken near Mulebbis (Jaffa district), 14.v.1918, in pursuit of a fast-travelling motor-car.

* *Cf.* Bull. Ent. Res., x, p. 293 (1920).

**Tabanus gigas,** Herbst.

One ♂, Nahr Rubin (coastal zone), 23.v.1921 (*I. Aharoni*) ; one ♀, Wadi Hamam, Galilee, 7.iv.1922 (*P. A. Buxton*). The latter specimen is the first ♀ of this species received from Palestine.

**Tabanus mendicus,** Villen.

One ♂, one ♀, Wadi Hamam, Galilee, 7.iv.1922 (*P. A. Buxton*).

Of this rare species, only two specimens of which have previously been recorded, (*cf.* Austen, *loc. cit.*, pp. 299–300), the ♂ was hitherto unknown. The dimensions of the example of this sex taken by Mr. Buxton in the Wadi Hamam are as follows :—Length, 12 mm. ; width of head, just over 4 mm. ; length of wing, 10 mm.

In general appearance of body, wings and legs the ♂ of *T. mendicus* resembles the ♀, so that there can be no doubt as to the specific identity of the two sexes, although in the ♂ the tergites of the first two (visible) abdominal segments, instead of being (as in the ♀) for the most part uniformly neutral grey or olive-grey pollinose, are, with the exception of the posterior angles and hind border of the second tergite, olivaceous-black. The *eyes* of the ♂, which, like those of the ♀, are densely clothed with light brownish or yellowish hair, consist for the greater part of their extent of enlarged facets of medium size, which on the lower, upper and outer borders merge into smaller facets without any abrupt transition. *Palpi* of ♂ dusky neutral grey, clothed, except outer and under surfaces of proximal segment, with long and fine black or blackish hair, outer and under surfaces of proximal segment clothed with long and fine yellowish hair, distal segment in ♂ cylindrical, swollen, rounded at tip. First and second segments of *antennae* in ♂ dark neutral grey pollinose, clothed for most part with blackish hairs mixed with a few yellowish hairs in case of first segment, latter strongly swollen towards distal extremity, third segment of ♂ antennae narrow, elongate, with no prominent angle on upper margin, velvety black in colour except extreme base, which is russet. Third and three following segments of ♂ *abdomen* shining black, third and fourth tergites clothed with fine, erect black or blackish hair, mixed, especially in centre and on hind border and posterior angles of fourth tergite, with similar yellowish hair, fifth and sixth, as also first and second tergites clothed mainly with fine glistening yellow or yellowish hair. *Wings* with *stigma* blackish-brown and very conspicuous, and with brownish suffusions extending along the third longitudinal vein from its base to that of its anterior branch inclusive, and across the base of the discal cell from the anterior transverse vein to the extreme base of the fifth posterior cell.

Viewed from above, the distal portion of the abdomen of the ♀, like that of the ♂, commencing with the third (visible) segment, appears uniformly shining black.

**Tabanus lunatus,** Fabr.

One ♀, 10 miles E. of Jerusalem, 17.iv.1922 (*P. A. Buxton*).

**Tabanus nemoralis,** Mg.

One ♂, Jerusalem, 15.iv.1922 (*P. A. Buxton*).

The specimen is the first ♂ of this species to reach the British Museum (Natural History) from any locality.

**Tabanus eggeri,** Schin.

One ♂, Rehoboth (Jaffa district), 20.vi.1916 (*I. Aharoni*).

This is the first example of the ♂ sex of *T. eggeri* to be received at the British Museum (Natural History) from any locality.

**Tabanus autumnalis,** Linn.

One ♀, Haifa, 7.v.1921 (*P. A. Buxton*).

**Tabanus arenivagus,** Austen.

*Tabanus arenivagus*, Austen, Bull. Ent. Res., x, p. 305, figs. 9, 10 (April 1920).

One ♀, Rehoboth (Jaffa district), 22.x.1920 (*I. Aharoni*).

The original series of *T. arenivagus* was taken (in the Wadi Ghuzze district) in September and October 1917, so that it is evidently a late species.

**Tabanus pallidipes,** Austen.

*Tabanus pallidipes*, Austen, Bull. Ent. Res., x, p. 316, figs. 15, 16 (April 1920).

One ♀, Zummerin, 22.viii.1920 (*Captain P. J. Barraud* : presented by the Imperial Bureau of Entomology).

The specimen just recorded is atypical as regards the coloration of the front legs, in which the femora are strongly infuscated and the tarsi black, while rather less than the distal halves of the tibiae are blackish-brown.

The type of this species, and a second example mentioned by the author in his original description, were obtained respectively near Jericho and at Jerusalem.

**Tabanus (Ochrops) kertészi,** Szil.

*Ochrops kertészi*, Szilády, Ent. Mitt., iv., Nr. 4/6, p. 99, Taf. III, fig. 2*a–g* (May 1915).

One ♀, Zikron Jakob (coastal zone), 17.v.1921 (*P. A. Buxton*).

This species, described by Szilády from four specimens, two of which were from Syria (Sarepta), while the provenance of the others was unknown, is the first representative of the subgenus *Ochrops* to be recorded from Palestine.

# ON SOME MALAYAN AND OTHER SPECIES OF *CULICOIDES*, WITH A NOTE ON THE GENUS *LASIOHELEA*.

By F. W. Edwards.

(Plate III.)

The main purpose of this note is to give a name to the Malayan *Culicoides* that sucks blood from the abdomen of Anopheline mosquitos, and thus to afford cover for the publication of some very interesting observations made recently upon this species by Dr. W. A. Lamborn. At the same time, some account is given of the very few additional specimens of Oriental *Culicoides* in the British Museum —most of which were also collected by Dr. Lamborn in Malaya ; and the opportunity is further taken to describe two other apparently new species of the genus, from Somaliland and Jamaica, respectively, which have recently been received at the Museum.

A note is added on the genus *Lasiohelea*, which seems to be, apart from *Culicoides* and *Leptoconops*, the only other Ceratopogonine genus of habitual blood-suckers. Some instances are given of the remarkably wide distribution of some members of these genera, showing the inadequacy of studying these insects merely from a regional point of view, as is more or less inevitably done by writers at the present time.

. . . . . .

The first record of a Ceratopogonine midge attacking a mosquito was that of C. J. Fearnside (Ind. Med. Gaz., xxxv, p. 128, 1900), who observed "*Culex III and IV*" being attacked at Rajahmundry Gaol. His published figure and description show that the midge he observed was a species of *Culicoides*, perhaps identical with that described below. He states that he had not seen the parasite on any *Anopheles*.

Subsequently Captain Norman Lalor and Dr. A. T. Stanton independently observed the phenomenon at Kyankpyu, Lower Burma, and Kuala Lumpur, F.M.S., respectively, and published notes describing their observations (Paludism, No. 5, pp. 42 and 64), without naming or describing the midge concerned. About the same time Gravely (Rec. Ind. Mus., vi, p. 45, 1911) recorded a similar discovery at Calcutta.

So far as I have been able to ascertain, the midge which has these remarkable habits has remained till now unnamed,* and I therefore describe it below. Since all the material which has been received at the Museum belongs to one species it seems probable that the records of Fearnside, Leland and Gravely, whose material I have not seen, also refer to the same species.

**Culicoides anophelis,** sp. n. (Plate iii, figs. 4–7).

♀.—Resembles the African *Culicoides fulvithorax* (Austen)† so closely that a complete description seems unnecessary ; the following are the only distinctions I have been able to discover :—Short sensory bristles present on most, if not all, of the first eight flagellar segments, though difficult to detect. The trilobed dark area on the anterior portion of the mesonotum is darker and more extensive, occupying at the maximum almost the anterior third of the mesonotum ; there is also a more or less extensive dark brown area immediately in front of the scutellum ; scutellum and

* Fearnside and Lalor both state their intention of describing the species in detail, but do not appear to have done so.

† Synonyms : *Johannseniella fulvithorax*, Austen, 1912 ; *Culicoides ochrothorax*, Carter, 1919 ; *C. fulvithorax*, Carter, Ingram and Macfie, 1920 ; *C. citrinus*, Kieffer, 1921.

postnotum blackish instead of moderately dark brown. The line of division between the ochreous upper and blackish-brown lower parts of the pleurae is not very sharply marked. The three spermathecae are equal in size and almost globular, not unequal and sausage-shaped. Ground-colour of wings rather lighter, and the pale spots rather larger. First radial cell rather broader, generally closed by a fairly definite cross-vein (though in some specimens it is almost as narrow as in *C. fulvithorax*). A few scattered macrotrichia on the membrane of the apical fifth of the wing (these are present also in Austen's type of *C. fulvithorax*, though not mentioned or figured by Carter for *C. ochrothorax*).

The British Museum possesses the following material :—

Malay Peninsula : Pudoh Gaol, Kuala Lumpur (*Dr. A. T. Stanton*) ; five ♀ still attached to the abdomens of ♀ specimens of *Anopheles hyrcanus, A. karwari* and *A. maculatus* ; also three other ♀♀ from *A. aconitus, A. fuliginosus* and *A. hyrcanus*. Kuala Lumpur (*Dr. W. A. Lamborn*) ; nine ♀♀ (mounted) from the species of *Anopheles* mentioned in the table below.

Sumatra : Deli (per *Dr. A. T. Stanton*), one ♀, host not stated.

N.W. India : Meenglas, Jalpaiguri, 26.vi.1921 (*M.O.T. Iyengar*) ; one ♀ on *A. maculatus*.

Dr. Lamborn's observations were made at Kuala Lumpur, F.M.S., between April 1920 and April 1921. During this period a very large number of Anopheline mosquitos were captured and examined, 26 of which were found to be attacked by the *Culicoides*. The following table, prepared by Dr. Lamborn, summarises these captures :—

| Species of Anopheline. | Males captured. | Females captured. | Number of *Culicoides* taken on the females. |
|---|---|---|---|
| *A. vagus*, Dönitz .. .. .. | 1,539 | 3,306 | 18 (two on one host) |
| *A. aconitus*, Dönitz .. .. .. | 2,541 | 3,212 | 2 |
| *A. karwari*, James .. .. .. | 6 | 17 | 3 (two on one host) |
| *A. fuliginosus*, Giles .. .. .. | 70 | 75 | 2 |
| *A. umbrosus*, Theo. .. .. .. | 21 | 256 | 3 (two on one host) |
| *A. hyrcanus*, Pall. .. .. .. | 74 | 213 | 1 |
| *A. subpictus*, Grassi .. .. .. | — | 46 | — |
| *A. barbirostris*, V. d. W. .. .. | 47 | 168 | — |
| *A. maculatus*, Theo. .. .. .. | 8 | 18 | — |
| *A. kochi*, Dönitz .. .. .. | 71 | 65 | — |
| *A. tessellatus*, Theo. .. .. .. | 107 | 183 | — |

No specimen of the *Culicoides* was found on a Culicine mosquito, but this was probably owing to the comparatively small number of these insects which was examined. In every case the parasites were found attached to some portion of the abdomen (generally on the sides of gorged individuals) of female *Anopheles*. The absence of parasites on the males, and on the thorax of the females, shows conclusively that the object of the parasite was to obtain the ingested blood, rather than the body-fluids of the mosquito itself, though Dr. Lamborn notes that in one or two cases no trace of blood could be found either in the host or the parasite. In other instances blood was present in both.

As had previously been noticed by Stanton, the parasites were not at all easily disturbed while at their meal, some remaining attached to the abdomen of the host even after the pair had been chloroformed. " These insects were in no wise disconcerted," says Dr. Lamborn, " even by the frantic endeavours of the captured Anophelines to escape." Observations showed that the parasites were either attached

by their mouth-parts only, entirely unsupported by their legs, or the front legs only were used in addition to the mandibles. They remained in this position for extended periods ; in several cases for more than 48 hours.

Dr. Lamborn's most complete series of observations were made on a specimen found on *Anopheles vagus*, Dön., taken in the servants' quarters attached to the house of a European at Kuala Lumpur. Regarding this specimen, he writes :—

" 11.iii.21. The host, replete with freshly absorbed blood, was taken with one of the parasites, the abdomen of which also showed bright pink, attached by its mouth-parts only to the third abdominal segment on the right side. On examination 48 hours later the parasite was seen to be still *in situ*, but at 9 a.m. on 14th March it was flying in the tube, free from its host. The tube containing the insect was then inverted over a bowl containing liquid mud, at the edge of which about 67 ova were found on 16th March. Five pupae were found on 23rd March on the surface film of water and 3 more on 25th March. Each of these afforded an imago on the third to fourth day."

Eggs were also obtained on other occasions ; in one case about 80, and in another 12. In the latter case the host showed no signs of having obtained a blood-meal.

Unfortunately neither males, larvae, nor pupae were represented in the material preserved by Dr. Lamborn, and presented to the British Museum, but apart from the bred specimens mentioned above, Dr. Lamborn writes that pupae were readily obtained from time to time, with those of the other species mentioned below, at the margins of small muddy pools, well in the shade.

No case of *Culicoides* parasitising other blood-sucking insects has yet been recorded from Africa, but the following observation of Dr. Lamborn's is of interest in this connection :—

" The facts [regarding *C. anophelis*] recalled to the mind of the writer an observation he made in 1916 in reference to *Glossina morsitans* in a fly area near the Tarengere River in Tanganyika Territory (and recorded in an unpublished report, dated 8th February 1917, to the Colonial Office), that some female flies exhibited on the lower surface of the abdomen dark patches with a central depression, suggesting puncture. No opportunity of ascertaining the cause of this arose. Dr. G. D. H. Carpenter suggested that it may have been due to attack by Tachinid flies, but a more probable explanation would seem to be that the flies are assailed by some insect for the purpose of depriving them of their ill-gotten meal, much as the Anophelines are attacked by the little *Culicoides*."

**Culicoides guttifer,** de Meij. (Plate iii, fig. 2).

Several males and one female of this species were reared by Dr. Lamborn from pupae " obtained at the margins of small, muddy pools, well in the shade," at Kuala Lumpur.

Both in regard to wing-markings and hypopygial structure the species shows a very close resemblance to the West African *C. praetermissus*, C. I. & M. The chief differences are that in the wings the small pale spot immediately below and distal to the second large costal spot, which is present in *C. praetermissus*, is absent in *C. guttifer* ; in the hypopygium, the lateral terminal processes of the ninth tergite are a little shorter and broader, and their terminal hairs are so minute as to be scarcely perceptible. Whether these small differences (I can find no others of any importance) indicate more than a varietal rank for *C. praetermissus* seems to me highly questionable. The single female mounted unfortunately does not show the spermatheca clearly, but it is probably single, as in the two allied African species.

So far as I can see, from an examination of the type, Kieffer's *C. leucostictus*, described from females only from the Seychelles Islands, is identical with *C. guttifer*. The European *C. pictipennis*, Winnertz, is also extremely similar.

**Culicoides oxystoma,** Kieff. (Plate iii, fig. 3).

Two females, which I take to be this species, were reared in company with *C. guttifer*. There are two points in which, if the above determination is correct, Kieffer's description is inexact. The clear areas of the wing-membrane, though appearing quite bare at a magnification of 100, are not actually so, very pale microtrichia being discernible under a magnification of 300. Secondly, the extreme tips of the femora and bases of the tibiae are blackish, the pale rings being sub-apical and sub-basal respectively, not actually apical and basal. Kieffer does not describe the thoracic markings in detail; possibly his specimen (described from Calcutta), like the two now before me, was a slide mount. The British Museum possesses a third specimen, obviously of the same species, from Bombay (*W. S. Hoseason*), so that it is evidently widely spread in the east, and has probably been described under other names. Patton's *C. kiefferi* (recently renamed *C. pattoni* by Kieffer) is evidently a very similar species, but differs (according to Patton's figure) in the absence of the small white spot beneath the second radial cell, and in having two conspicuous dark costal spots, the area between the second and third pale spots being darker than it is in *C. oxystoma*.

I would call attention also to the very close resemblance between this species and *C. maculithorax*, Williston, known from the West Indies and Brazil. Without having seen males of either, I cannot form an opinion as to how close the relationship is, but a comparison of Jamaican examples of *C. maculithorax* in the British Museum with Indian and Malayan *C. oxystoma* reveals only minute and seemingly unimportant differences; the most obvious of these are that *C. maculithorax* has rather fewer hairs on the wing-membrane, and a rather larger pale spot below the second radial cell, while segments 9–12 of the flagellum are a little more swollen at the base. The two forms agree in having two rather large, nearly globular spermathecae with rather long chitinised necks.

The life-history of a species determined as *C. oxystoma* has recently been described by Patel (Proc. 4th Entom. Meeting, Pusa, p. 272). From the figure of the adult given by the author it would appear that the species is almost certainly wrongly determined; at any rate, Patel's species is quite distinct in wing-markings from Dr. Lamborn's, and does not agree nearly so well with Kieffer's description as does the latter.

**Culicoides peregrinus,** Kieff.

A single female, which appears to be this species, was reared by Dr. Lamborn in company with *C. oxystoma* and *C. guttifer*; the wing is shown in Plate iii, fig. 1.

**Culicoides pungens,** de Meij. (Plate iii, fig. 11).

I am indebted to Dr. de Meijere for the loan of the type (mounted in balsam) of this species, and reproduce herewith a photograph of its wing. It is much smaller than *C. anophelis*, and although the rather faint wing-markings are not dissimilar in the two species, the venation is quite different, the second radial cell in *C. pungens* being so narrow as to be scarcely distinguishable, and very little longer than the first. The British Museum possesses an example of *C. pungens* from Deli, Sumatra, received through the Imperial Bureau of Entomology from Dr. A. T. Stanton in 1915.

**Culicoides arenarius,** sp. n. (Plate iii, fig. 12).

♀.—Colour almost uniformly light ochreous; flagellum and abdomen somewhat darkened; back of head rather dark brown; halteres whitish. Eyes narrowly but distinctly separated, the strip between them narrowed in the middle to less than the width of one facet. Palpi normal, the second (Carter's third) segment moderately enlarged. Antennae normal, practically as figured by Carter, Ingram and Macfie for *C. schulzei* (End.); last segment without terminal style; segments 4–10 about

one and one-third times as long as broad. Thoracic hairs and bristles mostly rather dark brown. Scutellum with two bristles near together in the middle, two more on each side, and rather numerous hairs which are very little smaller than the bristles. Spermathecae two in number, moderately large and nearly globular. Legs normal; first hind tarsal segment scarcely twice as long as the second, and scarcely half as long as the tibia; fourth tarsal segments cylindrical, as long as the fifth. Wings hyaline and entirely unmarked, surface rather densely and uniformly covered with greyish hairs. Radial cells both narrow, the lumen about as broad as one of the veins; second cell a little longer than the first. Cross-vein rather more oblique than usual.

BRITISH SOMALILAND: Burao, xi.1914–i.1915 (*Dr. R. E. Drake-Brockman*), "collected inside tent, biting at midday"; six ♀♀ (cotypes), presented to the British Museum by the London School of Tropical Medicine.

I know of no other described *Culicoides* with uniform ochreous thorax and entirely unspotted wings, but the species is an absolutely typical member of the genus, with no structural peculiarities.

**Culicoides loughnani,** sp. n. (Plate iii, fig. 9).

Black; mesonotum yellowish-brown, faintly lined (according to collector; the specimens were preserved in spirit and the true coloration lost). Wings with dark ground-colour, with pale spots and streaks.

Antennae with segments 2–9 nearly globular, 8 and 9 about one-third longer than broad; verticils about twice as long as each segment; sensory hairs three in number on each segment, about two-thirds as long as the verticils and nearly twice as thick. Segments 10-14 together about one-sixth longer than 2 9, 10–13 of equal length, 14 one-third longer, without stylet, all with long pubescence in addition to the basal verticils, but without sensory hairs. Palpi with the second joint considerably swollen, expanded on the inner side on the apical half, last two joints nearly cylindrical, each about twice as long as broad; together only half as long as the second joint. Mesonotum with short dark pubescence. Legs dark brown; a narrow whitish ring near the tip of each femur, and another near the base of each tibia; tarsi pale. First segment of hind tarsi rather more than twice as long as the second. Wings with dark ground-colour and paler markings (see figure); three black marks towards costa, the middle one darkest and broadest, covering the whole of the second and part of the first radial cell; pale streaks bordering the median and cubital veins. Whole surface with numerous macrotrichia, except for the costal and basal cells. Radial cells very narrow, the first half as long again as the second. Stem of median cell longer than the cross-vein. Halteres whitish. Length 1·3 mm.

JAMAICA: Kingston (*Major W. F. M. Loughnan, R.A.M.C.*), two ♀♀.

The collector notes that the species is common in Jamaica, and bites all through the afternoon, being most active as sunset approaches. In wing-markings it much resembles Williston's *C. maculithorax*, described from St. Vincent, which differs in having the wings hairy only at the tips, and a spotted mesonotum. *C. maculithorax* also occurs on the island, and its wing is figured (Plate iii, fig. 8) for comparison with that of *C. loughnani*. The difference between the two is almost exactly parallel to that between the Oriental *C. pattoni* and *C. oxystoma*.

**Culicoides loughnani** var. **jamaicensis,** n. (Plate iii, fig. 10).

Differs from *C. loughnani* as follows:—Wings darker, with a much larger dark area on the basal half of the costa; the spot over the radial cells, however, is not so conspicuously black; veins not pale-margined, except at the tips.

JAMAICA: Kingston (*Major W. F. M. Loughnan, R.A.M.C.*), two ♀♀, sent with *C. loughnani*.

The wing-markings are very similar to those of *C. phlebotomus*, Will., from St. Vincent, which has only the tips of the wings hairy.

## Genus **Lasiohelea**, Kieff.

*Lasiohelea*, Kieffer, Arch. Inst. Pasteur Afr. Nord, Algiers, i, no. 1, p. 115 (1921).
*Centrorhynchus*, Lutz, Mem. Inst. Oswaldo Cruz, v, p. 62 (1913); preoccupied by *Centrorhynchus*, Lühe, 1911 (Vermes).

The genus *Centrorhynchus* was proposed by Lutz for two Brazilian species, *C. stylifer* and *C. setifer*, the former being regarded as the genotype. Lutz's diagnosis is not very detailed, and it would seem that he meant the genus to include any biting CERATOPOGONINAE with completely unspotted wings. In a subsequent publication, Lutz identifies the previously described *Cotocripus caridei*, Bréthes, with his *Centrorhynchus setifer*, and proposes to adopt Bréthes' name *Cotocripus* for his genus.

The British Museum is indebted to Prof. R. Newstead and Mr. H. F. Carter for specimens of both *Centrorhynchus stylifer* and *C. setifer*, named by Dr. Lutz; the specimen of the former was taken from horses' ears at Villa Nova, Bahia, Brazil. In the writer's opinion, the two species are not congeneric, *C. setifer* (and therefore presumably *Cotocripus caridei*) being only a slightly modified *Culicoides*, without any empodium, while *C. stylifer* is quite different, belonging to the *Forcipomyia* group, with a well-developed empodium, and closely resembling in its venation and most other characters the European *Ceratopogon velox*, Winn. This resemblance between *C. stylifer* and *C. velox* clearly indicates that these two are congeneric, but since Lutz's name is preoccupied, and *Cotocripus* is shown not to be applicable, another name must be searched for.

Kieffer has recently (Ann. Mus. Nat. Hung., xvii, p. 23, 1919) described a so-called new species as *Atrichopogon pilosipennis*, and still more recently, in the paper quoted above, has introduced for this species the generic name *Lasiohelea*. Now *A. pilosipennis* is so similar to Winnertz's *C. velox* that it seems quite probable that the two are identical. Kieffer's name *Lasiohelea* may therefore be used to replace Lutz's *Centrorhynchus*.

The structural characters of *Lasiohelea*, as pointed out by Kieffer, are intermediate between *Atrichopogon* and *Forcipomyia*. It resembles the former genus in the structure of the antennae and in the venation, notably in the very long second radial cell, which extends well beyond the middle of the wing; this cell, however, is narrower than it is in *Atrichopogon*, the radius being almost in contact with the costa, while the first radial cell is obliterated by the fusion of $R_1$ and Rs.

On the other hand, the relationship to *Forcipomyia* is shown by the rather densely hairy wings, though the hairs are less close-lying than in *Forcipomyia*, and there are bare lines adjoining the veins, as in *Atrichopogon*. Among the larger hairs, which are spread over nearly the whole surface, can be distinguished small microtrichia, smaller than those of *Atrichopogon*, but more obvious than those of *Forcipomyia*.

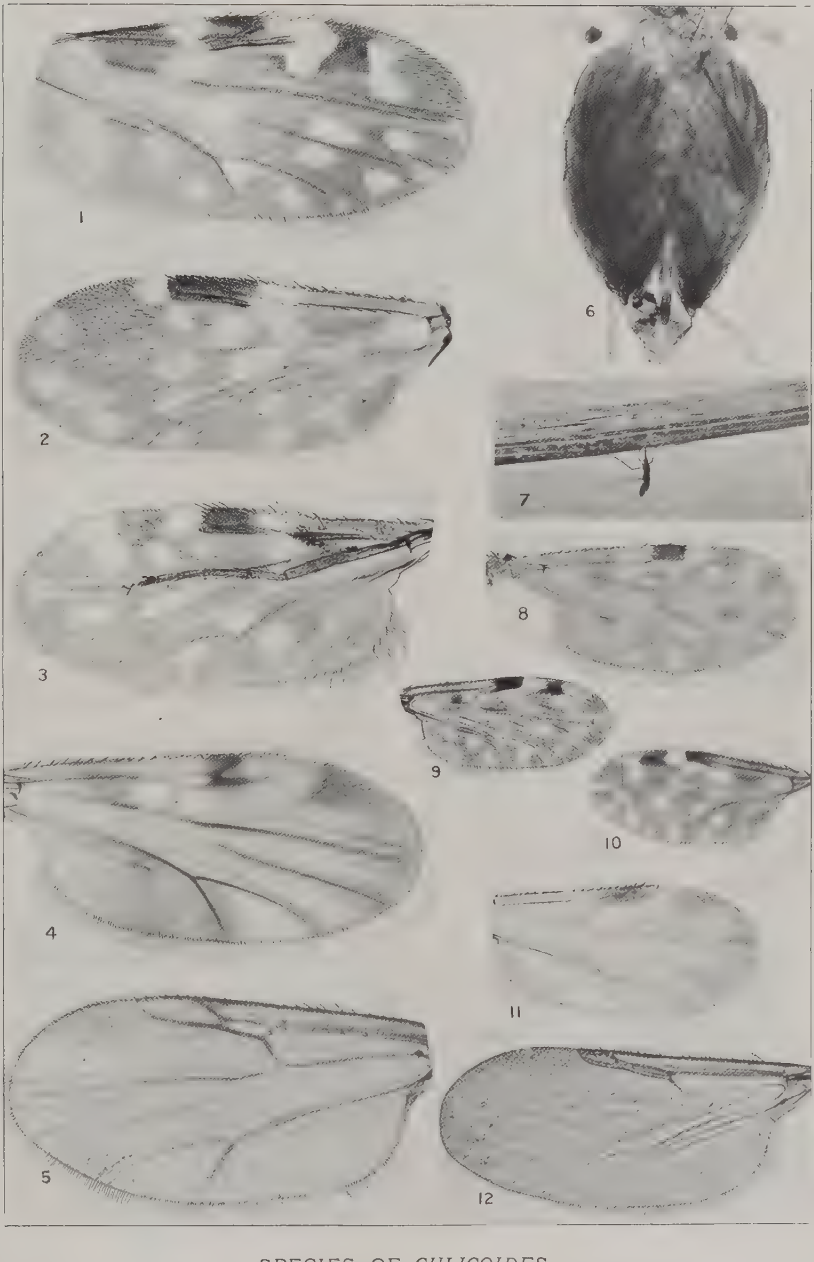
Besides *L. stylifer* (Lutz), of South America, and *L. velox* (Winn.) (*pilosipennis*, Kieffer), of Europe, two other described species may be referred to this genus. These are *Forcipomyia lefanui*, Carter, described from the Gold Coast, and *Ceratopogon stimulans*, de Meijere, described from Sumatra. These species are practically identical in structure with *L. stylifer*, and, like Lutz's species, are known to have blood-sucking habits. Of *L. lefanui*, the British Museum possesses a paratype obtained (biting) by Dr. Le Fanu on the Gold Coast, and also a long series collected by Dr. W. A. Lamborn at Ibadan, S. Nigeria. Of *L. stimulans*, the Museum has a specimen from Deli, Sumatra, received from Dr. A. T. Stanton; several from Peradeniya, Ceylon, collected (biting) by Messrs. E. E. Green and A. Rutherford; and a series of females, without doubt specifically identical with those from Ceylon, from various localities in Queensland, some collected biting or labelled "troublesome sand-fly," from Dr. T. L. Bancroft.

The genus *Lasiohelea*, then, is the third member of the CERATOPOGONINAE, whose species are mostly or all habitual blood-suckers, the one possible exception being

*L. velox*, a rare species whose habits have not been observed. It would seem that in this subfamily only the three genera, *Leptoconops* (sens. lat.), *Culicoides* and *Lasiohelea*, are regularly addicted to sucking the blood of mammals. Recorded cases of blood-sucking by members of any of the other genera are very few, and some even of these can be eliminated. Thus Meigen's statement, repeated by Verrall, that *Forcipomyia bipunctata* bites severely, is certainly due either to an error of identification, or to a more or less accidental occurrence ; the species is abundant in this country and has never been observed to bite within recent years. Austen's *Johannseniella fulvithorax*, taken in the act of biting, is really a *Culicoides*, as recently shown by Carter. De Meijere's *Ceratopogon salmi* and *C. vexans*, described as blood-sucking species, appear from the descriptions to belong either to *Forcipomyia* or *Dasyhelea*. Prof. de Meijere informs me that there is no actual evidence that they suck blood, the collector merely supposing them to be capable of doing so on account of the structure of their mouth-parts ; the specimens described by de Meijere were mostly captured at light. Malloch's record of the biting of *Dasyhelea grisea* stands alone so far as this genus is concerned, and confirmation is desirable ; I have seen no evidence that any of the British species of *Dasyhelea*, one of which is closely allied to *D. grisea*, ever attempt to suck blood. Kieffer has recently published a paper entitled "Nouveaux Chironomides piqueurs habitant le Sleswig-Holstein" (Ann. Soc. Sci. Bruxelles, Feb. 1922) in which various species of *Forcipomyia* and *Atrichopogon*, as well as *Culicoides* are described, but he adduces no evidence to show that any of the species are actually blood-suckers.

## EXPLANATION OF PLATE III.

Fig. 1. *Culicoides peregrinus*, Kieffer, wing, × 64.
,, 2. ,, *guttifer*, de Meijere, wing, × 64.
,, 3. ,, *oxystoma*, Kieffer, wing, × 64.
,, 4. ,, *anophelis*, sp. n., wing, × 64 ; maximum intensity of markings (balsam mount).
,, 5. ,, *anophelis*, sp. n. ; minimum intensity of markings (dry mount).
,, 6. ,, *anophelis*, sp. n., abdomen distended with eggs, × 46 ; the three spermathecae are visible to the left of the tip of the egg that is ready for deposition.
,, 7. *Anopheles fuliginosus*, attacked by *C. anophelis* ; photographed from nature by Dr. W. A. Lamborn.
,, 8. *Culicoides maculithorax*, Williston, wing, × 46 ; shown for comparison with *C. oxystoma* and *C. loughnani* ; specimen from Jamaica.
,, 9. ,, *loughnani*, sp. n., wing, × 32.
,, 10. ,, *loughnani*, var. *jamaicensis*, nov., wing, × 32.
,, 11. ,, *pungens*, de Meijere, wing of type, × 64 ; balsam mount, for comparison with *C. anophelis*.
,, 12. ,, *arenarius*, sp. n., wing, × 43 ; dry mount.




SPECIES OF *CULICOIDES*.

# ON THE AUSTRALIAN FERN WEEVILS.

By Guy A. K. Marshall, C.M.G., D.Sc.

(Plates VI–VIII.)

The weevil, *Syagrius fulvitarsis*, Pasc., has been known for some time as an enemy of ferns, Mr. W. W. Froggatt having found it abundantly attacking ferns both in greenhouses and in the open in the Botanic Gardens at Sydney.

In 1902 another species, *S. intrudens*, Waterh., was found to be doing serious damage to greenhouse ferns in the Royal Botanic Gardens, Dublin, and Prof. G. H. Carpenter recorded that in 1912 it had actually established itself and was breeding in the open (Econ. Proc. R. Dublin Soc., ii, no. 6, Aug. 1913). There can be little doubt that this species must have been introduced from Australia, but its original home has not yet been ascertained, and Dublin remains as the only locality from which it has been recorded.

In 1904 yet another species belonging to a different genus, *Neosyagrius cordipennis*, was described by Mr. A. M. Lea, the insect having been found by Mr. W. W. Froggatt damaging maidenhair ferns in the Botanic Gardens at Sydney.

Since about 1905 *Syagrius fulvitarsis* has been known to occur in the Hawaiian Islands in the vicinity of Honolulu, but it does not appear to have attracted any special attention until the last few years, when it has begun to spread to a somewhat disquieting extent and has started to attack the fern forests, the destruction of which might seriously affect the water supply. As the attempts to control it have not been altogether satisfactory, the Hawaiian Sugar Planters' Experiment Station arranged to send Mr. C. E. Pemberton to New South Wales in order to discover and bring back parasites of the weevil, a task which he has successfully accomplished.

Mr. Pemberton also brought back a number of the weevils found attacking wild ferns, and these have been kindly submitted to me by Mr. F. Muir for identification. The material, upon examination, proved to comprise no less than seven different species, namely, *Syagrius fulvitarsis* and four undescribed species of the genus, and two new species of *Neosyagrius*; neither *S. intrudens* nor *N. cordipennis* was represented. One of the new species of *Syagrius*, represented by a single specimen, is not dealt with here because examples of it have already been submitted by Mr. Pemberton to Mr. A. M. Lea, who proposes to describe it.

The types of the new species will be deposited in the British Museum, and in those cases in which there is more than one specimen there are cotypes in the collection of the Hawaiian Sugar Planters' Experiment Station.

### *Key to the Species of* Syagrius, *Pasc.*

1 (4). Interval 3 of elytra with a rounded granular tubercle at a little distance from the base.

2 (3). Funicle with joint 2 much longer than 1; dorsal outline of pronotum almost straight (apart from the median tubercles), but sloping markedly upwards in front; tubercles on elytra high and well marked, the intervals on the inflexed margins without granules .. .. .. .. *fulvitarsis*, Pasc.

3 (2). Funicle with the two basal joints subequal; dorsal outline of pronotum markedly convex; tubercles on elytra low and mostly ill-defined, the lateral intervals with flattened shiny granules .. .. .. *intrudens*, Waterh.

4 (1). Interval 3 of elytra with a large elongate granular tubercle that extends right up to the base.

5 (8). Rostrum not constricted at the base; femora rugosely granulate; tarsi clothed above with very fine hairs.

6 (7). Funicle with the two basal joints subequal; elytra not constricted at the base, the lateral intervals entirely without granules .. .. *costicollis*, sp. n.

7 (6). Funicle with joint 2 distinctly longer than 1; elytra constricted at the base, the lateral intervals with flattened shiny granules .. *pembertoni*, sp. n.

8 (5). Rostrum shallowly constricted laterally at the base; femora not granulate, almost smooth; tarsi clothed above with long stout flattened fulvous setae .. .. .. .. .. .. .. *squamipes*, sp. n.

**Syagrius costicollis,** sp. nov. (Plate vi, fig. 3).

♂♀.—Integument dull black, without scaling, but with sparse fulvous setae. *Head* very minutely aciculate on the vertex and with very shallow, sparse punctures; the forehead very coarsely punctate, with two low median elevations separated by a rather deep depression. *Rostrum* with the whole surface minutely aciculate, and therefore opaque in the ♂, but the dorsal area more shiny in the ♀; coarsely and closely punctate, except on the apical area, on which the punctures are small, shallow and separated (♂), or more or less longitudinally confluent (♀); the dorsal area rather indistinctly tricarinate, the outer carinae uniting into a point at the base, and the dorsal outline strongly and regularly curved; a deep, straight, shallowly punctate furrow on each side above the scrobe. *Antennae* red-brown; the two basal joints of the funicle subequal, the remainder slightly transverse, joint 7 more distinctly so; the basal joint of the club shorter than the rest of the club. *Prothorax* a little broader than long, strongly rounded at the sides, widest well before the middle, the anterior dorsal margin gently arcuate; a broad, smooth, flat median costa that reaches neither base nor apex, the remainder of the surface coarsely and confluently punctate, and the ridges between the punctures subtuberculate, there being two median tubercles higher than the rest, one on each side of the costa; the apices of most of the tubercles shiny, the rest of the surface opaque; a few sparse, short, recumbent setae, these being denser along the basal margin. *Elytra* suboblong, the sides not narrowed or constricted at the base; the rows of punctures shallow and rather irregular on the disk, much deeper and quite regular laterally; interval 1 bearing a few, irregularly spaced, minute granules along the suture; interval 2 narrow and very indefinite, with still fewer and variable granules; interval 3 with a large elongate basal tubercle set with shiny granules, a few granules at the middle, a slightly raised cluster of granules just behind these, a large rounded granular tubercle at the top of the declivity rather densely clothed with fulvous setae, and an elongate granular tubercle on the declivity; interval 4 almost without granules; interval 5 with irregular clusters of granules throughout, the one at the top of the declivity tuberculate and elongate; interval 6 almost smooth; interval 7 with a row of indistinct granules and a small tubercle at its apex; the lateral intervals devoid of granules. *Legs* rugosely granulate; the femora with an indefinite ring of pale setae at one-third from the apex; the tarsi red-brown.

*Length*, 3·4–5 mm.; breadth, 1·25–1·85 mm.

NEW SOUTH WALES: Nimbin, near head waters of Richmond River, iv.1921 (*Pemberton*).

Described from 28 specimens.

Readily distinguished from both the previously described species of *Syagrius* by the form of the basal tubercle on interval 3 of the elytra, which is elongate and extends right up to the base so that its upper surface continues the level of the dorsal outline (*cf.* Plate vi, fig. 4, *a*); whereas in the other two species this tubercle is rounded and placed at an appreciable distance from the base (Plate vi, fig. 6, *a*). It is further distinguished from all the species here dealt with by the fact that the elytra are not narrowed or constricted at the base.

**Syagrius pembertoni,** sp. nov. (Plate vi, fig. 4).

♂♀.—Integument dull black, with shiny granules, and sparsely set with short, recumbent, fulvous setae.

*Head* with the vertex very finely and transversely aciculate and sparsely set with minute flattened granules ; the forehead broadly tumid, covered with larger shiny granules and with a shallow median longitudinal impression. *Rostrum* almost straight in the basal half and then strongly curved, rather thicker dorso-ventrally in the ♂, but otherwise similar in the two sexes, with coarse reticulate punctation, except on the apical area, which is shining and finely punctate ; the dorsum with a very ill-defined median carina, without definite lateral carinae, and not narrowed to a point at the base ; a deep longitudinal furrow just above the scrobe. *Antennae* red-brown ; the funicle with joint 2 much longer than 1, the remainder about as long as broad ; the basal joint of the club as long as the remainder. *Prothorax* a little broader than long, strongly rounded at the sides, broadest slightly before the middle, the anterior dorsal margin distinctly arcuate ; the whole surface deeply and rugosely punctate, most of the spaces between the punctures bearing a shiny granule, the granules being more numerous along the front margin, and in the middle of the disk two low, granular tubercles, between which there is often an abbreviated, flat, smooth line ; on each side of the dorsum a curved stripe, formed of fulvous setae, extending from the base to about two-thirds of the length. *Elytra* oblong-ovate, narrowed and shallowly constricted at the base, thence nearly parallel-sided to far beyond the middle, the basal angles slightly projecting ; the punctures moderately deep, in quite regular rows and each containing a recumbent fulvous seta ; interval 1 with an intermittent row of minute granules, and with rather numerous fulvous setae on the posterior half ; interval 2 with a row of larger shiny granules (often irregularly duplicated) beginning at one-fourth from the base and ending not far behind the middle, this portion often slightly elevated and sometimes broadly interrupted in the middle ; interval 3 with a very large elongate basal tubercle, which is broadest and slightly projecting at the base and tapers to a point behind, being densely covered with shiny granules ; at or behind the middle on interval 3 an elongate aggregation of granules, at the top of the declivity a larger granular tubercle, and a smaller rounded or elongate one on the declivity ; interval 4 with two groups of granules similar to and in about the same position as those on interval 2 ; interval 5 with a cluster of granules near the base, another at the middle, and a low, granular tubercle at the top of the declivity ; intervals 6 and 7 with scattered smaller granules, and the lateral intervals with rows of sparse, shiny dots representing obsolescent granules. *Legs* coarsely granulate, with sparse, small, pale, recumbent setae ; tarsi red-brown.

*Length*, 5–6·25 mm. ; breadth, 1·75–2·5 mm.

New South Wales : Nimbin, iv.1921 (type), and Dunoon, near Lismore, iv.1921 (*Pemberton*).

Described from 17 specimens.

**Syagrius squamipes,** sp. nov. (Plate vi, fig. 2).

♂.—Integument dull black, without scaling, but with numerous short, stout, recumbent, fulvous setae ; the elytra with a few whitish squamiform setae at the basal junction of intervals 7 and 9, and an indefinite stripe of similar pale setae running from the summit of the tubercle at the top of the declivity on interval 3 obliquely forwards to the suture, forming with its fellow a faint chevron-shaped marking.

*Head* with fairly large, very shallow punctures throughout, except on the extreme vertex, which is transversely striolate ; the forehead without prominences, but strongly convex and with a deep longitudinal median fovea. *Rostrum* fairly strongly curved and with a shallow basal constriction on each side in front of the eye ; the dorsal area with irregular subconfluent setigerous punctures as far as the antennae,

without any median carina (except for a trace anteriorly), and the feeble lateral carinae converging to a distinct point at the base; the lateral area with two rows of deep setigerous punctures, but lacking the usual deep furrow above the scrobe; the apical area very shiny and distinctly but unevenly punctate. *Antennae* piceous; the funicle with joint 2 longer than 1, the others all a little longer than broad. *Prothorax* somewhat transverse, strongly rounded at the sides, broadest at the middle, and the anterior dorsal margin subtruncate; the whole surface set with large rounded tubercles of unequal size, most of them having a minute shiny granule at the summit, but without the usual two higher tubercles in the middle; the dorsal outline rising gradually from the apex to well behind the middle, then falling rapidly, the base being well below the level of the apex. *Elytra* slightly pyriform, shallowly constricted at the base, then very gradually widening posteriorly, being widest at three-fourths the length, the basal angles projecting laterally; the punctures very large and deep, and in fairly regular rows even on the disk; intervals 3, 5 and 7 more or less tuberculate, the others plane and not even granulate, all the tubercles bearing a few minute shiny granules; interval 3 with a large elongate basal tubercle (the basal margin being there produced slightly forwards), followed by three subtuberculate groups of granules, then a large rounded tubercle at the top of the declivity, and an elongate elevation on the declivity itself; intervals 5 and 7 with the tubercles well marked behind, but becoming much reduced or obsolete towards the base. *Legs* almost smooth, the femora with some very shallow punctures at the apex and base, and with sparse, fulvous setae, and an ill-defined ring of paler setae on the thickened portion; the tibiae with dense, raised squamiform fulvous setae; the tarsi black, and with similar setae instead of the usual fine hairs.

*Length*, 8·5 mm.; breadth, 3·5 mm.

New South Wales: Nimbin, 20.iv.1921 (*Pemberton*).

Described from a single male.

This is the largest species of the genus and differs from all the others in the following points :—The basal constriction of the rostrum and the absence of the deep lateral furrow; the comparatively smooth legs, and the dense squamiform setae on the tibiae and tarsi.

In the genus *Syagrius* the genitalia of both sexes afford good diagnostic characters (*cf.* Plates vii, viii). In the males the median lobe is in the form of a shallow trough with only the lateral and anterior edges heavily chitinised; the dorsal surface of the tube is entirely membranous, and on the ventral portion there is a lightly chitinised, elliptical or ovate area, above which lie two short, slightly curved rods, which are pointed posteriorly; the median struts are continuous with the lateral margins of the median lobe, thin and sinuate dorso-ventrally at the junction with the lobe, but compressed distally and more or less spatulate at the apex; the length of the struts in relation to that of the median lobe is as follows in the various species (using the same unit of measurement throughout, 8 units = 1 mm.) :—*S. fulvitarsis*, 8 : 5; *S. intrudens*, 11 : 8; *S. costicollis*, 10 : 9; *S. pembertoni*, 16 : 8. The uneverted sac extends almost to the apex of the struts in *intrudens* and *fulvitarsis*, whereas in the other two species it reaches to about the middle of the struts; but the most striking specific differences are to be found in the very large and complex transfer apparatus at the end of the sac, which are well shown in Mr. Jobling's excellent drawings. The spiculum is of the usual form—a stout rod, with a Y-shaped fork at the attached end, and the free end strongly curved and somewhat spatulate. The eighth ventrite is lightly chitinised, with a hyaline median stripe, and the basal margin is very deeply bisinuate.

In the female genital tube the vaginal palps are of quite normal form and extremely similar in the three species examined (*fulvitarsis*, *pembertoni* and *costicollis*), and in the specimen of *fulvitarsis* figured (Pl. viii, fig. 5) the palps are 0·1 mm. long and the supporting plates 0·75 mm. In the bursa copulatrix is a more or less complicated chitinous structure, which differs markedly in each species (Pl. viii, figs. 2–4), its

function apparently being to engage with the equally complex transfer apparatus of the male in order to bring the orifice of the ductus ejaculatorius opposite the duct leading to the spermatheca. The characteristic eighth ventrite (Pl. viii, fig. 6) is very similar in the three species, only differing slightly in the form of the angulated free end.

The preparations from which figures 2, 3, 5 and 6 on Plate vii were drawn were kindly lent to me by Mr. F. Muir.

## Genus **Neosyagrius,** Lea.

**Neosyagrius porosus,** sp. nov. (Plate vi, fig. 5).

♂♀.—Integument dull black or piceous, unevenly clothed with pale brownish scales of very different sizes.

*Head* shiny and bare on the vertex and with shallow reticulate punctation; the forehead quite flat, with dense scaling, which conceals the sculpture. *Rostrum* with the dorsal outline almost in the same plane as that of the forehead as far as the antennae, then sloping rather abruptly; the flat portion opaque, very finely shagreened, densely squamose like the forehead and indistinctly tricarinate, with a longitudinal impression on each side just above the sinuous carina that forms the upper margin of the scrobe; the apical area rather more shiny, shallowly punctate, and with a sparse band of very small scales between the apices of the scrobes. *Antennae* with the scape strongly bisinuate in the basal half, the apical half broadly clavate, the outer face grooved for the reception of the funicle, the posterior edge with a sharp carina that does not reach the apex, the anterior face clothed with long, subrecumbent, squamiform setae; the funicle with joints 1 and 2 very long and subequal, 3 as long as broad, the rest becoming progressively shorter and more transverse. *Prothorax* subquadrate, as long as broad, with the sides subparallel in the middle for more than half its length, and narrowing rather more at the apex than at the base, the basal margin broadly rounded; the whole surface covered with deep, coarse, subreticulate punctures, the apical area depressed much below the level of the somewhat tumid disk, which is traversed by a broad, deep, longitudinal furrow that widens at the base; the spaces between the punctures finely shagreened and bearing flattened, subrecumbent, brown setae. *Scutellum* minute, triangular. *Elytra* ovate, broadest near the base and rapidly narrowing behind, narrower in the ♂; the basal margin strongly sinuate, with the external angles projecting forwards, the lateral areas markedly inflexed, and the apex obtusely rounded in the ♀ and almost subtruncate in the ♂; the dorsal outline in the ♀ rising abruptly at the base, then almost flat to the middle, then sloping strongly and becoming almost perpendicular behind, in the ♂ more convex in the basal half and less steep behind; the very shallow striae each containing a row of large spaced punctures (containing no granules), those in stria 7 smaller than those in 8 and 9, and the punctures in row 10 (which is complete) much smaller still; the intervals smooth, without granules or punctures, and here and there connected together by higher transverse septa in the striae, the depression at the base of the suture being very shallow; the unequal curved subrecumbent scales fairly dense at the base from the shoulder to stria 2 and on irregular transverse patches on the disk and declivity, elsewhere on the disk sparse and uneven, the lateral inflexed areas being quite bare. *Legs* stout, the femora strongly clavate, the front pair rather thicker than the others; the squamiform setae elongate, fairly dense and fulvous, subrecumbent on the femora, more raised on the tibiae, and the femora without a pale ring. *Venter* with long, curved, suberect, flattened setae; in the ♂ the first visible ventrite with a very deep median impression containing numerous fine erect setae, its posterior margin bearing two transversely laminate small erect tubercles; the anal ventrite of the ♂ broadly impressed and with large shallow punctures.

*Length*, 3–3·5 mm.; breadth, 1·6–2 mm.

New South Wales: Dunoon, iv.1921 (*Pemberton*—type); Nimbin, iv.1921 (*Pemberton*).

Described from four specimens.

Very similar to the genotype, *N. cordipennis*, Lea, the only species described up to the present, which differs in the following particulars:—The scales or setae are throughout much shorter, broader and quite recumbent; the prothorax is slightly transverse; the elytra are more distinctly striate, with the intervals more regular and convex, the basal sutural depression is much deeper, every puncture bears a minute granule on each side projecting over the edge, and the posterior declivity is vertical in the ♂; the posterior femora bear a pale patch of scales externally near the apex; on the venter of the ♂ the setae are short and recumbent, the basal ventrite is merely flattened and the anal one is convex and finely rugulose.

**Neosyagrius striatus,** sp. nov.

♂.—Integument black to piceous, shiny, thinly but fairly evenly clothed with whitish scales and golden-yellow setae.

Elongate-ovate, much narrower than either of the other two species, from which it differs also in its shiny integument and more deeply striate elytra; moreover, the pronotum is less flattened and the sides much less steep. The setae on the prothorax are much narrower than those of *cordipennis*, and even rather finer than those of *porosus*, which are dark brown instead of golden-yellow. The elytra are broadest at about one-fourth from the base, and rapidly narrowed behind, the apex being obtusely rounded; the punctures bear a minute granule on each side; the scales and setae are narrower and more evenly distributed than in the other two species, being entirely recumbent; the scutellar depression is much shallower than in *cordipennis*, and there are no transverse elevations as in *porosus*. The setae on the femora are sparse, narrow and recumbent, and there is no pale ring; in *porosus* they are slightly broader, denser and not quite recumbent, being somewhat curved; whereas in *cordipennis* they are very broad and scale-like, lie quite flat, and form a pale ring near the apex on the posterior pairs. The venter of the ♂ has the disk of the first visible ventrite flattened, very coarsely punctate and shiny, and with the usual two tubercles on the posterior margin; the anal ventrite is slightly convex in the middle and coarsely punctate; the setae are short, sparse, narrow and recumbent.

*Length*, 2·75 mm.; breadth, 1·25 mm.

New South Wales: Nimbin, iv.1921 (*Pemberton*).

Described from a single male.

## EXPLANATION OF PLATE VI.

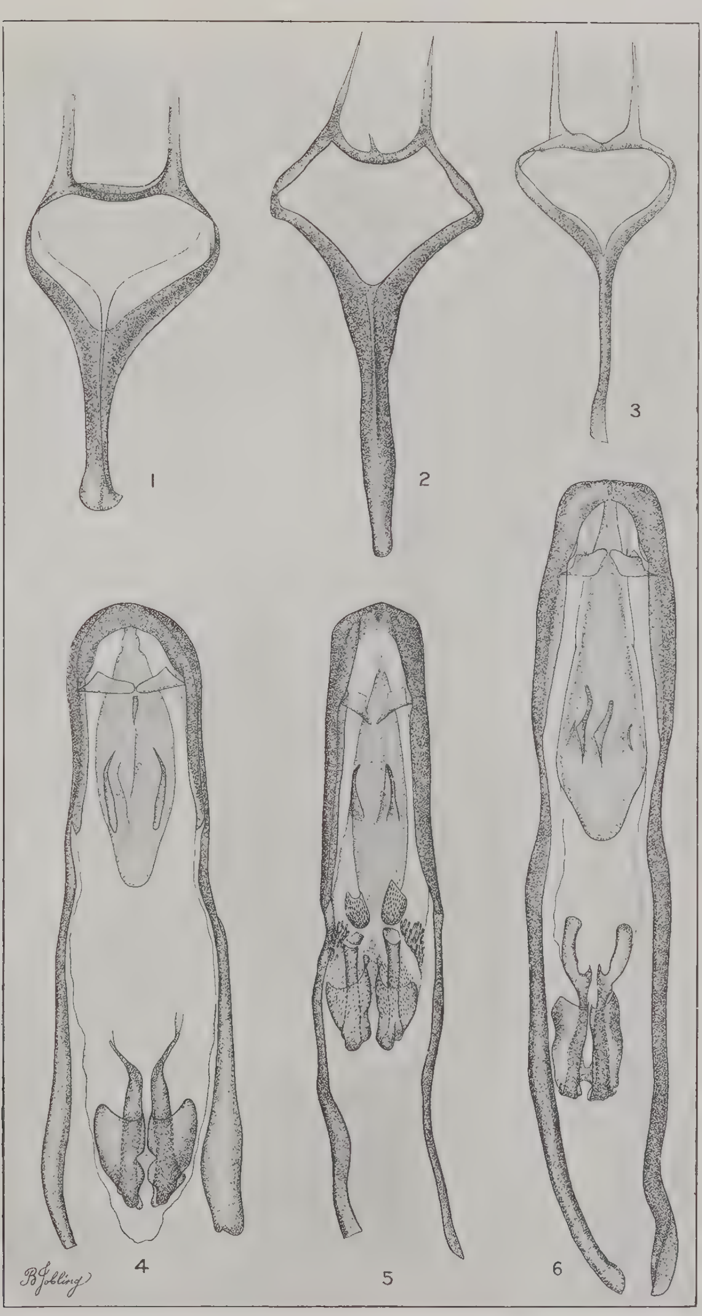
Fig. 1. *Syagrius fulvitarsis*, Pasc.
,, 2. ,, *squamipes*, Mshl., sp. n.
,, 3. ,, *costicollis*, Mshl., sp. n.
,, 4. ,, *pembertoni*, Mshl., sp. n.; *a*, lateral view.
,, 5. *Neosyagrius porosus*, Mshl., sp. n.
,, 6. *Syagrius intrudens*, Waterh.; *a*, lateral view.


AUSTRALIAN FERN WEEVILS.

## EXPLANATION OF PLATE VII.

Male genitalia of *Syagrius*.

Fig. 1. Tegmen of *S. intrudens*, Waterh.
,, 2. ,, *S. pembertoni*, sp. n.
,, 3. ,, *S. costicollis*, sp. n.
,, 4. Aedoeagus of *S. intrudens*, Waterh.
,, 5. ,, *S. costicollis*, sp. n.
,, 6. ,, *S. pembertoni*, sp. n.

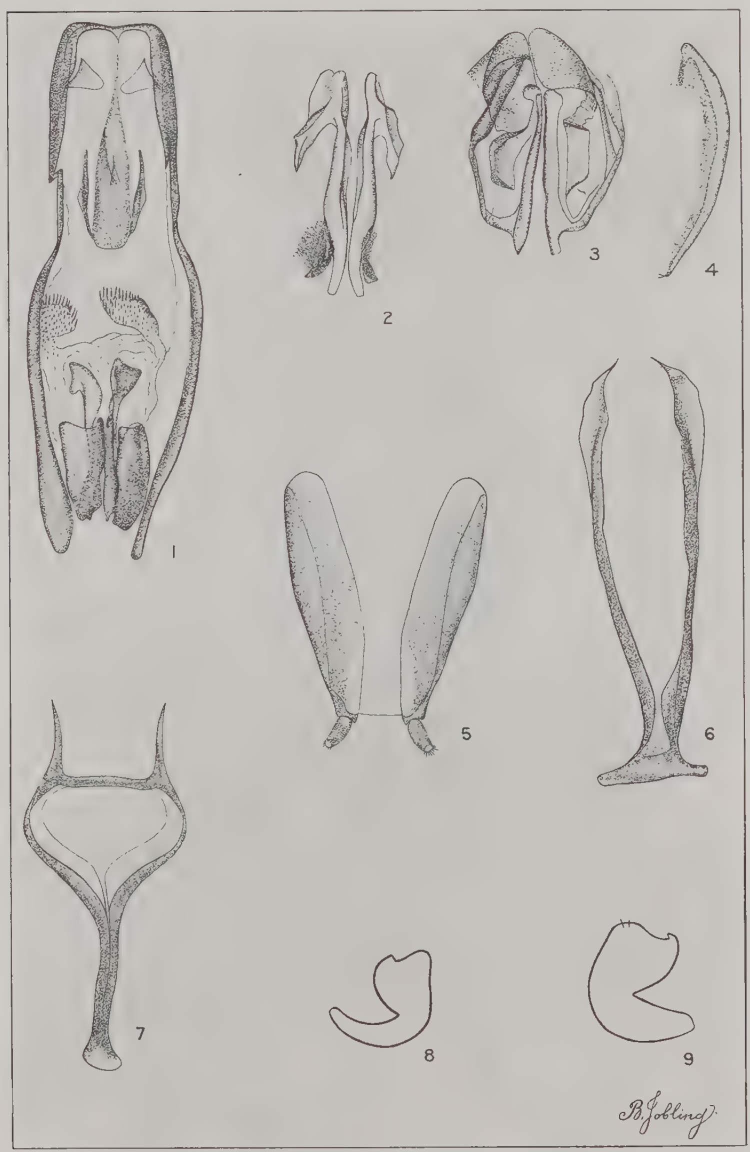



MALE GENITALIA OF AUSTRALIAN FERN WEEVILS.

## EXPLANATION OF PLATE VIII.

Male and Female Genitalia of *Syagrius*.

Fig. 1. Male aedoeagus of *S. fulvitarsis*, Pasc.
,, 2. Chitinous structure in bursa copulatrix of *S. fulvitarsis*, Pasc., ♀, ventral view.
,, 3. ,, ,, ,, ,, ,, ,, *S. costicollis*, sp. n., ♀, ,, ,,
,, 4. ,, ,, ,, ,, ,, ,, *S. pembertoni*, sp. n., ♀ ,, ,,
,, 5. *S. fulvitarsis*, vaginal palps of ♀.
,, 6. ,, 8th ventrite of ♀.
,, 7. ,, tegmen of ♂.
,, 8. ,, spermatheca of ♀.
,, 9. *S. pembertoni*, ,, ,,




MALE AND FEMALE GENITALIA OF AUSTRALIAN FERN WEEVILS.

# NOTE REGARDING TYPES OF SOME TACHINIDAE (DIPTERA) FROM INDIA.

By J. D. Tothill, D.Sc.,

*Entomological Branch, Ottawa, Canada.*

In this Bulletin for May 1918 (Vol. ix, pt. 1) some species of Tachinidae were described from India. It was the intention at the time to deposit the types in the British Museum (Nat. Hist.), but owing to war conditions it was considered advisable to retain them in Canada until a later date. In March of this year (1922) the type material was sent to the British Museum ; a set of paratypes of most of the species was retained for the National Collection at Ottawa ; and another, but larger, set of paratypes was sent to Mr. C. F. C. Beeson, the Forest Entomologist, at Dehra Dun, India. The species concerned are :—

*Gymnochaeta immsi*, Tothill.
*Servillia transversa*, Tothill.
*Servillia ursinoidea*, Tothill.
*Gonia himalensis*, Tothill.
*Paraphania fuscipennis*, Tothill.
*Chaetoplagia asiatica*, Tothill.
*Frontina kashmiri*, Tothill.
*Lophosia excisa*, Tothill.

[Major E. E. Austen, D.S.O., after examining Dr. Tothill's types, has supplied the following notes on synonymy, etc. :—

*Servillia transversa*, Tothill = *S. sobria*, Walk. (1852), Ins. Saund. Dipt., pt. iv, p. 272.
*Servillia ursinoidea*, Tothill = *S. fulva*, Walk. (1852), *op. cit.*, p. 276.
*Gonia himalensis*, Tothill = *G. capitata*, De Geer.
*Paraphania fuscipennis*, Tothill = *Orectocera beelzebub*, Wied., of which *Tachina imbrasus*, Walk. (1849), is also a synonym.
*Frontina kashmiri*, Tothill, should be referred to *Podomyia*, B. & B.
*Lophosia excisa*, Tothill, is probably a *Phania*.—Ed.]

# TWO NEW CHALCIDOID PARASITES.

By James Waterston, B.D., D.Sc.

The Imperial Bureau of Entomology has recently received from Fiji two examples of a Trichogrammatid bred from eggs of a Hispid, *Promecotheca reichei*, Baly, that mines in leaves of coconuts, and through the kindness of Dr. G. A. K. Marshall this material has been handed to me for examination. As received, the specimens (mounted in glycerine under the same cover glass) were too shrivelled to be studied satisfactorily. After some colour notes had been made, the wings of each specimen were detached and mounted. The bodies were then thoroughly potashed (10 per cent.) and transferred to glacial acetic in which, owing to their original pallor, they practically disappeared. They were accordingly stained for one minute with carbol fuchsin (Grübler), washed again in acetic acid, and gradually brought up to pure clove oil in which the dissection of one example was completed. Although it is unfortunately

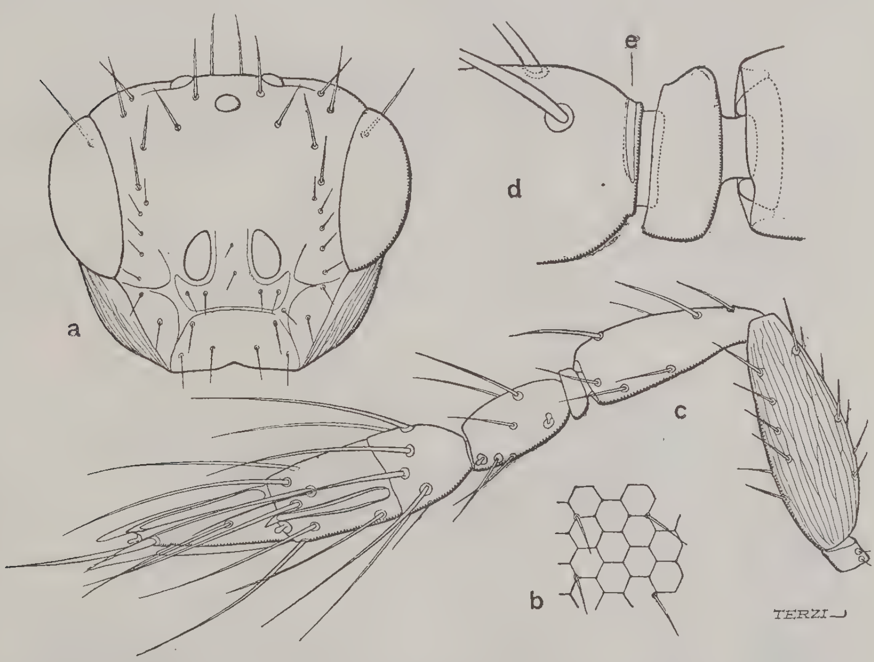



Fig. 1. *Chaetostricha cratitia*, Waterst., sp. n.: *a*, head; *b*, portion of eye; *c*, antenna; *d*, detail of ring joint and first funicular; *e*, membranous sulcus.

still no easy matter to determine the genera of the Trichogrammatidae, I have no hesitation in assigning the insects under discussion to *Chaetostricha*, Walker, in interpreting which I agree with Dr. Kryger's views in his paper on "The European Trichogramminae" (Entomologiske Meddelelser, xii, pp. 303–305, 1918). The ring joint in this genus is solid, but in both examples examined the funicular joint at the extreme base shows a clear, nearly complete, weakly chitinised ring, which must give additional flexibility to the antenna at this point.

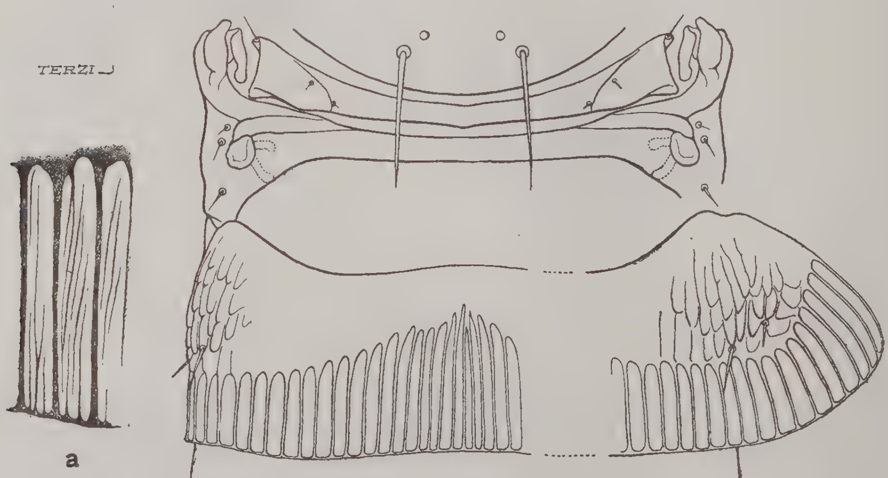
**Chaetostricha cratitia,** sp. n.

A pale yellow species very faintly infuscated at the bases of the abdominal tergites and below the ovipositor. A slight cloud below stigma. Possibly also the tips of the tarsi and the antennae towards the apex may be slightly darker than the body.

Head, seen from in front (fig. 1, *a*), about one-fifth broader than deep (23 : 19). Eyes sparsely pilose (fig. 1, *b*), half as long again as the genal keel and separated, at their nearest, by rather less than two-thirds of the breadth of the head. Genae long and considerably swollen behind the keel. Clypeal edge nearly straight, with a slight median notch. Toruli (3 : 2) well up on the face, their lower edge just on the base line of the eyes; separated by their longer diameter and from the orbit by a diameter and one-third. Chaetotaxy as in fig. 1, *a*. Besides the bristles shown there are, on each side of the vertex near the stout bristle (touching the orbit), which is partly dotted, 2 minute bristles more remote from the orbit on the occipital slope. On each of the swollen genae are some half dozen minute bristles.

Antenna, length, 0·4 mm. (fig. 1, *c*); the scape, pedicel and funicular joint are in ratio 38 : 28 : 17, and the club segments 14 : 18 : 22. The breadths of the antennal joints vary considerably according to the pressure to which they are subjected; thus on the same scale the breadth of the scape is 12–13; pedicel, 10–12; funicle, $9\frac{1}{2}$–11; club, 11–13 : 11–12 (at sutures). The first segment of the club bears 7–8 long bristles in all and no sensoria; second segment, 8–9 bristles and 2 sensoria; apical segment, 1 lateral bristle, 4 sensoria, and 1 stout terminal bristle as long as the supporting segment. There are also 3 minute but stout knob-like sensoria set in sockets; 1 at the apical ventral angle of the funicular joint, another (lateral) near the base, and 1 laterally on the second club segment, on the suture between it and the third.

Mandibles (10 : 7) similar, tridentate, the long bristle on the ventral edge *not* unusually thickened. Stipes with 1 long lateral bristle and 1 median, shorter, opposite the base of the palpus. Galea with 2 stout spinose bristles at side distally and about 24 short fine bristles on inner surface. Mentum with 2 long bristles; 4 setigerous cells on lingua.




a

Fig. 2. *Chaetostricha cratitia*, Waterst., ♀: from apex of scutellum to hind margin of first abdominal segment; *a*, detail of structure of first tergite towards hind margin.

Thorax. Pronotum collar-like, consisting of 2 triangular tergites, spiracular emargination slight and shallow; pattern fine, long drawn out transversely; each tergite bears 5 bristles; 2 near middle, 2 beside the spiracle and 1 anteriorly. Mesonotum with median weak line, pattern very fine, longitudinally drawn out so that the whole surface appears to be delicately striate; 1 stout bristle at each antero-lateral angle; parapsides with 1 lateral bristle; axillae with 2 minute bristles; scutellum with 2 stout bristles, admedian in position, 1 beside each of the clear sensory pustules (fig. 2). Metanotum very short and broad, the propodeon consists of a median area, which is narrow and riband-like and 2 lateral triangular expansions; spiracle broadly oval, with 2 minute bristles outside and 1 behind (fig. 2). The mesophragma extends almost through three segments and is nearly two-thirds the breadth of the abdomen. Prosternum and propleurae bare. Mesosternopleurae smooth and bare except for 1 minute bristle at the posterior edge of the small and closely united prepectus and another below the forewing on the upper edge of the episternite.

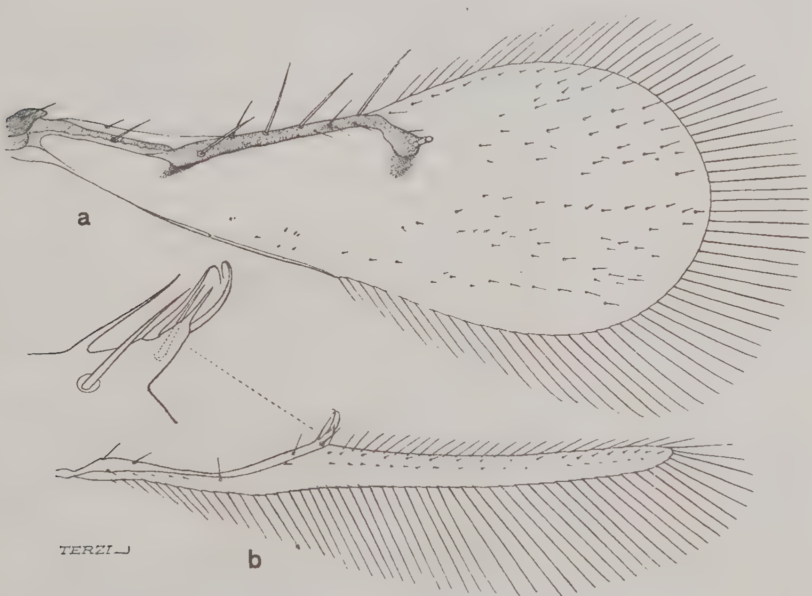



Fig. 3. *Chaetostricha cratitia*, Waterst., ♀: *a*, forewing; *b*, hindwing.

Wings. Forewing (fig. 3, *a*) (8 : 3): length, 0·76 mm.; breadth, 0·28 mm.; not including the marginal cilia, of which the longest (0·125 mm.) are at the distal posterior angle. The longest cilia are distinctly not half the greatest breadth of the wing, though they are two-thirds or more as long again as the radius. The neuration reaches to rather more than half the wing length.

Hindwing (fig. 3, *b*) (about 13 : 1): length, 0·68 mm.; breadth, 0·05 mm. The longest of the marginal cilia are three times the breadth (0·15 mm.). Discal ciliation as in figure, the second row being just in advance of the mid line.

Legs. Forelegs: length, 0·71 mm.; 1 stout apical femoral bristle; dorsal edge of tibia apparently simple, without tooth-like prominences; first tarsal joint with about 6 lateral ventral spines.

Mid legs: length, 0·84 mm.; coxa (6 : 5) with 3 bristles posteriorly on apex. Trochanter slender, as long as coxa or three-sevenths of the femur (5 : 1). The latter much shorter (2 : 3) than the tibia (12 : 1), with about 10 short bristles along the dorsal edge, 7–8 and an apical spine in a subdorsal posterior row and 5 in an antero-median row; the apical ventral bristle is rather weak. The tibia has 7–8 widely spaced spines dorsally, 2 at the base being stronger; 8–9, minute, anteriorly (one row) and about 18 in all, stronger, posteriorly, arranged in two rows from the middle to apex but in a single row on basal half; 7–8 ventral spines on apical half, apical spine only one-third of the 1st tarsal joint. The tarsal joints bear on the plantar surface a double row of thin hyaline spines, and there are besides the following lateral spines, one apical on 1st and 2nd joints, and one beyond half on the first joint.

Hind legs: length, 0·95 mm.; coxa (2 : 1) pear-shaped, as long as the femur (11 : 5), externally bare, and with 2 spinose bristles at apex and 2 more (minute) near base on inner surface. The femur bears a dorsal row of bristles (10), and on upper anterior surface two more rows of 6–7 each. The last unit (distal) of all these is a spine, so that anteriorly at apex the femur has an oblique row of 3 spines; there is besides, anteriorly, a moderately long bristle near base, above ventral edge; the distal spine, long and stout, is placed well before the apex; posteriorly the femur bears 8–10 bristles in two rows. Tibia (10 : 1) rather more than half as long again as the femur; its dorsal edge denticulate, with about a dozen short spines, of which one or two at the base are stronger; on ventral edge (on apical half) 8–9 spines, on the anterior surface about 12 bristles and one or two fewer posteriorly; apical surface posteriorly much roughened, comb of 5–6 spines; the apical spine equal in length to that of mid tibia, only stouter. Tarsus similar to that of mid leg; proportions of tarsal joints: foreleg, 26 : 27 : 26; mid leg, 45 : 33 : 25; hind leg, 45 : 33 : 27.

Abdomen conic ovate, longer than head and thorax together. The 7th (9th) segment from above triangular. Ovipositor very shortly extruded. The segments (from above) subequal. Tergites peculiarly constructed, a basal band of variable width being chitinised and emitting thin sub-parallel chitinous ribs to the hind edge. Between the ribs the tergite is exceedingly thin, this membranous area being traversed in turn by extremely delicate chitinous rays or wrinkles. The 1st (3rd) tergite (fig. 2) has 50–60 of these major ribs and at each side a group of raised cells.

Chaetotaxy. Each tergite has 1 bristle at the side, accompanied in the case of tergite 1 by a second much smaller. In the middle tergites 1–4 are bare, while tergites 2–6 have 2 bristles (1, 1) about the mid line; tergite 7 has 10 bristles (5, 5). The first sternite is bare; 2–4 bear 2 bristles (1, 1), median in position. The last sternite bears 6 bristles in all, 2 at each side and 2 below the ovipositor. The sting is relatively stout, with 6 teeth at apex.

Length, about 0·9 mm.; expanse, 1·8 mm.

*Type* ♀ in the British Museum; one of 2 ♀♀ bred from ova of *Promecotheca reichei*, a Hispid beetle injurious to the foliage of coconut (*Cocos nucifera*) Cicia, Fiji, 7.xii.1921 (*H. W. Simmonds*, No. 809), and received from the Imperial Bureau of Entomology.

*Chaetostricha cratitia*, sp. n., is closely allied to *C. schlickii*, Kryger (*l.c.* p. 307, 1918), from Dyrehaven, Denmark (host unknown). In the Danish species the scape and pedicel are subequal, and the funicular joint a little less than half the club, which again is shorter than the pedicel, ring joint and funicular joint combined.

### Genus **Encyrtus**, Dalm.

**Encyrtus cotterelli,** sp. n.

♀.—Head, legs entirely (except empodia and last joint of hind tarsus), prothorax, mesoscutum, axillae, mesosternopleurae, and propodeon (except on mid-third dorsally) clear cinnamon (a little paler on legs); scutellum, metanotum, middle of propodeon and abdomen dark brown with metallic reflections, which on the abdomen

are purplish and more violet on the scutellum. Fifth hind tarsal joint and all empodia infuscated. Eyes chocolate (after spirit). Forewings slightly tinted throughout, clearer on proximal third and with a large median cinnamon-brown cloud ; nervures brown. Hind wings nearly hyaline.

Except for the duller metanotum, the whole dorsal surface is remarkably smooth and shining.

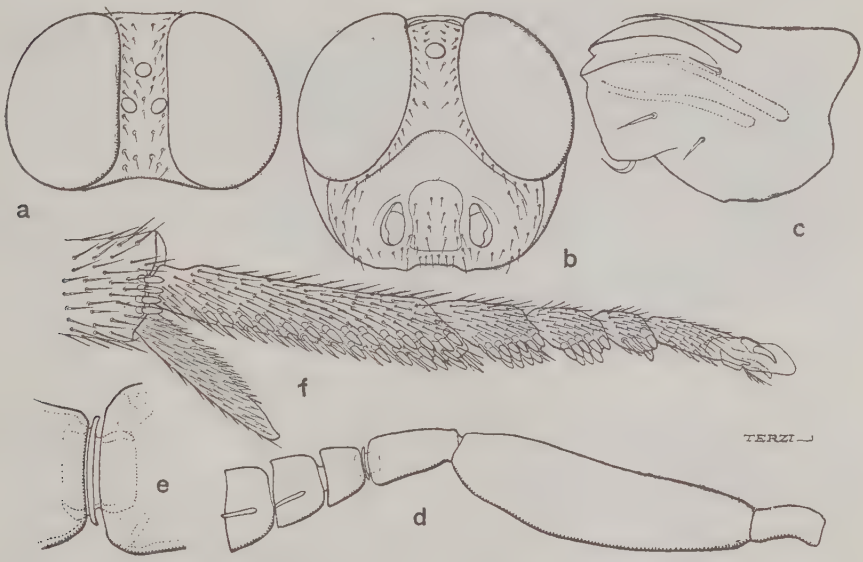



Fig. 4. *Encyrtus cotterelli*, Waterst., sp. n.: *a*, head from above; *b*, head from in front; *c*, mandible; *d*, basal half of antenna; *e*, ring joint of antenna; *f*, mid tarsus.

*Head* from in front wider (12 : 11) than deep (fig. 4, *b*), clypeal edge straight. Eyes with very short scattered pubescence, in profile occupying two-thirds of the depth of the head and so large that at the level of the anterior ocellus they are separated by only one-sixth and at the base line by about two-thirds of the width. Toruli (12 : 7) set low down, not half their length from the clypeal edge, and separated by one and a half lengths from one another. The frons is practically smooth and bare, save for the usual row of orbital bristles, but the inflexed face is finely striate-reticulate, becoming more normally reticulate towards the genal keel. About 20 bristles between the toruli. The narrow vertex (fig. 4, *a*) is smooth, with the ocelli in an isosceles triangle. Antenna (fig. 4, *d*, *e*) with scape (7 : 2) not greatly flattened, three and a half times as long as the pedicel (7 : 4), which is as long as the first two funicular joints. Ring joint minute. Funicle joints (first three) equal, and if the length is taken as 15 the breadths are 18, 24, 28. The second funicular joint bears six sensoria.

Labrum narrow, slightly concave, with eight bristles. Mandibles (see fig. 4, *c*). Stipes with one bristle. Palpus slender, the lengths of the joints as 17 : 14 : 11 : 23 ; joints 1, 3 and 4 of equal breadth (6), the second a trifle wider (7) ; a dozen stouter bristles at edge of galea, the upper surface of which is densely set with fine bristles. Joints of labial palpus as 15 : 5 : 10. Lingua with 10 setigerous cells.

*Thorax.*—Mesoscutum about one-sixth longer than the scutellum ; the latter, flat, somewhat conic, and very smooth posteriorly. Metanotum strongly rugulose, especially at the sides. Propodeon broadly smooth medianly and faintly reticulate

on each side towards the broadly oval spiracle, which is set at its own length from the anterior edge. Round the spiracle (exteriorly) and towards the hind edge the surface is striate ; on the mesopleurae the pattern is drawn out finely anteriorly, but becomes more regular posteriorly.

*Wings.*—Forewings (12 : 5), length 1·3 mm., breadth 0·56 mm. (fig. 5). Hindwings (18 : 5), length 0·9 mm., breadth 0·25.

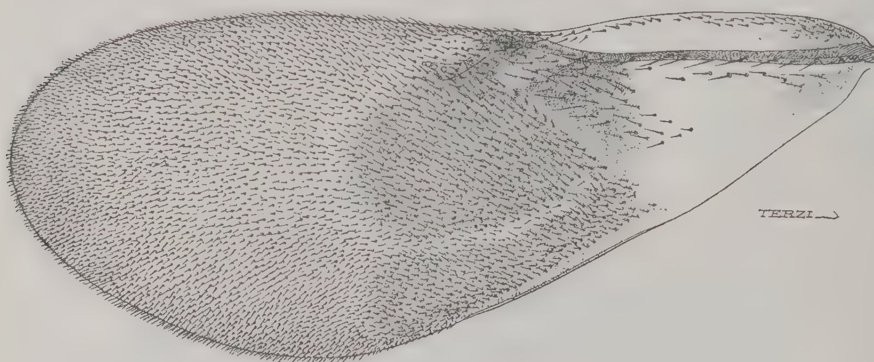



Fig. 5. *Encyrtus cotterelli*, Waterst., ♀, forewing.

*Legs.*—Fore femur (4 : 1) knife-like, retaining its maximum breadth for about three-fourths of its length. Mid femur and tibia of equal length, the latter with four peg-like spines at apex posteriorly ; spur three-fourths as long as the 1st tarsal joint. Tarsus (fig. 4, *f*). Hind tibial comb with about 18 spines.

| *Tarsus.* | *Fore Leg.* | *Mid Leg.* | *Hind Leg.* |
|---|---|---|---|
| 1st joint .. .. .. | 40 | 85 | 80 |
| 2nd joint .. .. .. | 27 | 28 | 40 |

*Abdomen*, though smooth and shining, with the mid dorsal surface finely and regularly reticulate. Medianly tergites 1–5 are bare, with a few bristles at the sides. Ventrally the abdomen is covered rather closely with minute bristles. The ovipositor tip is barely visible from above and the free portion of the sheath is one-fifth the base.

*Length*, 3·2 mm.

*Alar expanse*, 1·6 mm.

*Type* ♀ in British Museum.

Three examples were bred from a third instar nymph of the Capsid bug, *Sahlbergella theobromae*, Dist., which is injurious to cacao (*Theobroma cacao*), at Mampong, Ashanti, Gold Coast, West Africa, by Mr. G. S. Cotterell, January 1922, and two of these were received by the Imperial Bureau of Entomology from Mr. W. H. Patterson, Government Entomologist, Aburi, Gold Coast.

In neither specimen is there a complete antenna and the general condition of both is poor, so that their placing has been a matter of difficulty. I have assigned them provisionally to the genus *Encyrtus*, Dalm., to which they run down, but with which, however, they do not quite agree, partly because of their mandibles, but chiefly from the smooth thoracic notum and flat scutellum. My friend, Dr. R. G. Mercet, Madrid, considers that, while showing certain of the characters of *Encyrtus*, these *Sahlbergella* parasites should be regarded as constituting a distinct genus.

# THE LARVAL AND PUPAL STAGES OF THE BIBIONIDAE.—PART II.

By Hubert M. Morris, M.Sc., F.E.S.

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(Plate IX.)

In previous papers (1917,1921) accounts have been given of four species of the genus *Bibio*, and the present paper deals with two species of the genus *Dilophus*, viz., *D. febrilis*, L., and *D. albipennis*, Mg. They are the commonest species of *Dilophus* in Britain, and both frequently occur in great numbers.

*Dilophus febrilis* has often been recorded as causing damage to the roots of plants, especially hops, in the larval state. This species may be double-brooded, adults appearing in May, and again in smaller numbers in August and September. *D. albipennis* appears to have only a single brood, which appears in May. In both species the larva has four instars, separated by ecdyses. No complete account of these larvae appears to have been given hitherto. The larva and pupa of *D. febrilis* have been figured by Curtis (1844) and by Cameron (1913).

I am much indebted to Dr. A. D. Imms for suggestions and advice during the course of this work.

## **Dilophus febrilis**, L.

*Oviposition.*

In *Dilophus febrilis* the circle of spines at the distal extremities of the anterior tibiae appear to be of some use to the female in making her way into the soil for the purpose of oviposition. The fly burrows into the earth by pressing the soil aside by this means. The eggs are laid in a mass in a cell in the soil in a similar manner to those of *Bibio marci*, as figured in a previous paper (Morris, 1921).

The depth of the soil with which the flies were supplied was only 2·5 cm., but several masses of eggs were laid at that depth, against the bottom of the vessel.

*Egg.*

The eggs of *Dilophus febrilis* (fig. 1) are cylindrical and slightly curved, with rounded extremities, the diameter at one end being slightly greater than at the other. When first laid the eggs are white, but they soon darken at both extremities. The chorion bears numerous slight projections. The length of the eggs is 0·55 mm. and their breadth 0·15 mm.

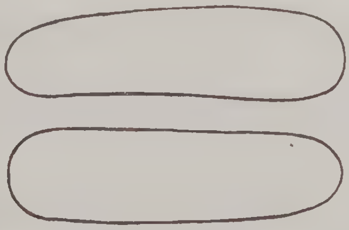

Fig. 1. Eggs of *Dilophus febrilis*, L., ×120.

Eggs laid on 19th May and kept in the laboratory, hatched on 7th and 8th June, and those laid on 21st May hatched on 11th June, the incubation period thus being 18–20 days.

*First Stage Larva (newly hatched).*

The newly hatched larva (Plate ix, fig, 1) is about 1·05 mm. long, and about 0·16 mm. in breadth. The length of the head is 0·15 mm. The latter region is relatively large, of a pale yellowish-brown colour, and bears several long setae.

The body is colourless and transparent, the contents of the alimentary canal showing through as a dark median line. The body is divided into 12 segments, each bearing several short and rather stout setae, arising from enlarged conical bases. In addition to these there are a great number of smaller, rather conical projections, each bearing from 1–4 minute spines, these structures being similar in appearance to the scale-like structures of the fully grown larva.

The larva at this stage bears a single pair of spiracles, which is situated on the twelfth segment, in a position similar to that occupied by the spiracles of that segment in the fully grown larva. The mouth-parts do not show any very marked differences from those of the adult larva, the most noticeable being the presence of two projections between those at the anterior end of the labium, whereas only one occurs in the fully grown larva.

*Second Stage Larva.*

In this stage the larva is about 2 mm. in length and about 0·22 mm. in breadth. The head is brown and shining, and bears several long setae. The mouth-parts are similar to those on the first stage larva ; the median anterior processes of the labium are, however, rather less well developed.

The body is pale brown in colour, and bears short stout setae and spine-bearing conical scales similar to those of the first stage larva.

The larva in this stage is readily distinguished from the newly hatched larva, in addition to its larger size, by differences in the tracheal system. The second stage larva is amphipneustic, having a pair of spiracles situated laterally near the posterior margin of the first body segment, and a second pair borne more dorsally, in a position similar to those on the corresponding segment of the fully grown larva, on the twelfth segment. The spiracles of the latter pair still have only a single aperture. There is no indication, in this stage, of the stout conical processes which are characteristic of the fully grown larvae of this family.

No material of the third stage larva was preserved.

*Fourth Stage Larva (fully grown).*

A number of larvae were found amongst decaying grass on 27th January, and on the next day some of them were observed to undergo ecdysis. When fully grown the larva is from 10–12 mm. in length, and about 1·5 mm. in breadth. The length of the head is about 1 mm. (fig. 2).

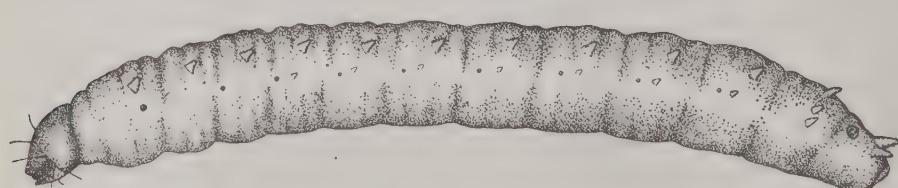

Fig. 2. Fully grown larva of *Dilophus febrilis*, ×18.

The head is dark brown and shining, and bears several long setae. The mouth-parts and antennae (figs. 3–6) do not show any very marked differences from those of other Bibionid larvae, the most noticeable being the presence of a well developed median projection at the anterior end of the labium.

The body is light brown in colour and almost cylindrical, but somewhat flattened dorso-ventrally; it is normally slightly curved, with the ventral surface concave, and is divided into 12 segments, of which the first is the largest.

Fig. 3. Right mandible of larva of *Dilophus febrilis*, × 140.

Fig. 4. Left maxilla of same, ventral view, × 140.

There are 10 pairs of spiracles,* a pair on each segment, except the second and eleventh, and they project slightly from the body. The spiracles on the first segment are situated laterally near the posterior margin of the segment; those on segments 3-10 are situated laterally near the anterior margins, and are about half the size of those on the first segment. The spiracles on the twelfth segment are in a more dorsal position near its anterior margin, and are about twice the size of those on the first segment. Each posterior spiracle has three openings (fig. 7), although there appears to be an occasional tendency for two of the openings to fuse, so that the spiracle then has only two openings.

Fig. 5. Labium of larva of *D. febrilis*, ventral view, × 140.

Fig. 6. Antenna of same, × 870.

Each segment bears a few stout conical processes similar to those of *Bibio* larvae, but in this species they are fewer in number and smaller. The first segment bears a single pair of processes of moderate size, each process lying immediately above the spiracle. Segments 2–10 bear each a similar pair of processes in a dorso-lateral position at about the middle of the segment. In addition, segments 4–10 bear a smaller pair of processes just posterior to the spiracle. The eleventh segment bears a row of 6 processes on its dorsal surface, somewhat behind the middle of the segment, and the twelfth segment has a row of 4 rather larger processes near its posterior margin.

* In the account of the larva of *B. marci* (Morris, 1921), owing apparently to a flaw in the block, the spiracles on the fifth and sixth segments are omitted in fig. 3.

The cuticle bears many small scale-like structures, similar to those of *Bibio* larvae, each being provided with 1–4 short sharp-pointed spines (fig. 8). Almost all the scales in this species bear spines, whereas in *Bibio* larvae they occur only on the

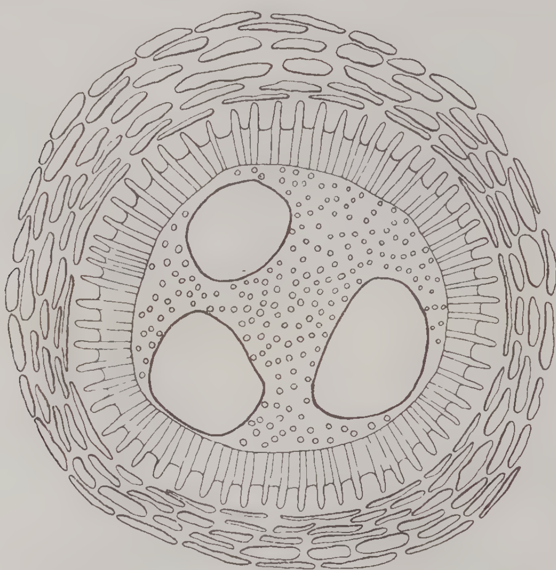

Fig. 7. Posterior spiracle of larva of *Dilophus febrilis*, ×720.

larger scales. The spines on the scales on the processes are longer than those found elsewhere, and 2 appears to be the most frequent number of spines on each scale in this position; the number, however, varies from 1–4. In addition to these scales, the cuticle bears several fairly stout and moderate-sized setae dorsally and ventrally on each segment.

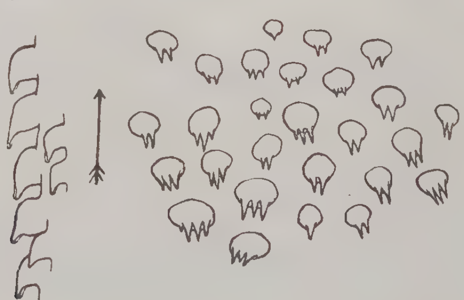

Fig. 8. Cuticle of larva of *Dilophus febrilis* from dorsal surface of fourth segment, showing lateral and dorsal views; the arrow is directed anteriorly; × 500.

The *alimentary canal* (Plate ix, fig. 2) of *Dilophus febrilis* has been figured by Keilin (1919). It is almost straight, but the hind gut forms a loop at the posterior end of the body. It has three anterior caeca, the largest of which is ventral, and a

very well developed posterior caecum opening ventrally from near the posterior end of the mesenteron, and directed anteriorly. The anterior caeca have a lobe at their anterior end, these lobes having almost the appearance of three small additional caeca. The Malpighian tubes enter the alimentary canal by a very short common duct, as is the case in *Bibio* larvae.

*Pupa.*

Elongate, cylindrical, tapering gently to posterior end, abruptly at anterior end. Completely free from larval skin. Colour at first white, head and thorax of imago showing dark through cuticle later. Length, 7·5 mm.

*Male* (fig. 9). Head with 3 conspicuous pointed processes at anterior end, 1 median and 2 slightly ventral to it arising from the eyes, which are large and conspicuous.

Fig. 9. Pupa of *Dilophus febrilis*, ♂, ventral view, ×18.

*Female* (fig. 10). Head with a single stout median process at anterior end. Eyes much smaller than in the male.

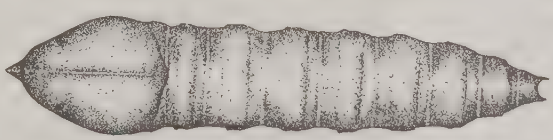

Fig. 10. Pupa of *Dilophus febrilis*, ♀, dorsal view, ×18.

*Male and female.* A slight dorsal ridge extends from anterior median process to posterior margin of thorax, along which dehiscence for the emergence of the imago occurs. Antennae extremely short, arising between bases of eyes, and extending laterally over eyes, with a small conical process on base. Labium elongate, semicircular ; labial palpi elongate, extending laterally. Dorsally most of head covered by prothorax, only eyes of male visible.

Thorax strongly arched dorsally. The thoracic spiracles slightly projecting laterally. Tibiae and tarsi of forelegs extending from side of eyes level with antennae to anterior margin of second abdominal segment, with tarsi in apposition along median line. Second and third pairs of legs parallel to first ; all except tibiae and first and last tarsal segments of second, and last tarsal segment of third, covered by wings.

Abdomen nine-segmented, tapering to posterior end, the ninth segment being conical. Cuticle with many wrinkles, mainly transverse. Abdominal segments, dorsally and ventrally, bearing numerous spines similar to those of the larva, usually occurring singly on slight swellings of the cuticle. Terminal segment bearing a pair of stout pointed processes at the posterior end, directed posteriorly and outwards, and a pair of rounded papillae anterior to them, on which the spiracles of this segment are situated. Each segment of abdomen, except eighth, bearing a pair of slightly projecting spiracles situated laterally towards the anterior margin of the segment.

Segments 1–7 with a stout blunt process posterior to the spiracle ; all the segments except last with a slight ridge dorsally and ventrally towards the posterior margins, the ridge on the dorsal surface of the eighth segment bearing two pairs of short blunt processes.

*Note on Imago.*

Out of 278 larvae which were reared, including those killed in the pupal stage, 140 were females and 138 males. This slight excess of females is rather surprising, as in the field there usually appears to be a considerable excess of males. The males, on the whole, emerged earlier from the pupa.

## **Dilophus albipennis,** Mg.

*Egg.*

In the case of *Dilophus albipennis* oviposition is carried out in a similar manner to that of *D. febrilis*. Females of this species were observed to oviposit at depths of 6·5 cm., 7·5 cm. and 5·0 cm. in the soil.

The eggs are similar to those of *D. febrilis*, but are slightly larger, being about 0·62 mm. long, and about 0·15 mm. broad. Eggs laid on 31st May 1920 and kept in the laboratory were observed to hatch on 30th August 1920, 91 days later. Eggs laid between 30th May and 1st June 1921, and also kept in the laboratory, hatched between 19th September and 22nd September 1921, 112–116 days later.

*First Stage Larva (newly hatched).*

The first stage larva has no apparent difference from that of *Dilophus febrilis*, but is slightly larger in size, being about 1·3 mm. long and about 0·16 mm. broad.

*Second Stage Larva.*

The larva in this stage appears to differ very slightly from that of *Dilophus febrilis* in the corresponding stage. The only apparent difference is that the 2 median anterior processes on the labium of the larva of *D. febrilis* are, in the case of *D. albipennis*, replaced by a single median process.

*Third Stage Larva.*

The larva in the third stage appears, except for its smaller size, to be almost indistinguishable from the fully grown larva. The stout conical processes of the body are present in the same positions as in the full-grown larva.

The tracheal system is peripneustic, with ten pairs of spiracles, which are arranged as in the fully grown larva. Each spiracle on the last segment has two openings, of which the posterior one is distinctly larger than the other.

*Fourth Stage Larva (fully grown).*

The larva in this stage is distinguished from the corresponding stage of *D. febrilis* by the absence of all the stout conical processes excepting those on the eleventh and twelfth segments, these being similar to those of *D. febrilis*. The structure of the mouth-parts and of the scales on the cuticle appears to be identical, and the alimentary canal is also similar to that of *D. febrilis*.

*Pupa.*

There appears to be very little difference in either sex from the pupa of *D. febrilis*. The only difference appears to be that the processes at the anterior end are slightly less well developed in this species than in the former.

## Differences between the Larvae and Pupae of Bibio and Dilophus.

The larvae and pupae of these two genera, in so far as the various species have been studied, appear to be quite easily distinguishable. The newly hatched larvae of *Bibio* are characterised by their very long setae, the larvae of *Dilophus* at this stage having only short setae. They are further distinguishable by the presence of many small spines on the cuticle in *Bibio*, *Dilophus* having groups of 1–4 similar but still smaller spines in the same position ; also the *Bibio* larva has a single median process at the anterior end of the labium, the *Dilophus* larvae having a pair of processes in this position. The newly hatched larvae of these genera agree in the presence of a single pair of spiracles situated on the twelfth segment.

The fully grown larvae are also quite readily distinguishable. The most striking difference is the smaller number of processes in *Dilophus* larvae as compared with those of *Bibio*. They may also be distinguished by the posterior spiracles of *Dilophus* having 3 openings, while those of *Bibio* have only 2. In addition there is a well-developed median process at the anterior end of the labium, which, in the species so far examined, is absent or very slightly developed in *Bibio*.

Male pupae are distinguishable by the presence of 3 well-developed conical processes at the anterior end in *Dilophus*, instead of the single process in this position in *Bibio* pupae, which in some cases is very slightly developed. Female pupae of *Dilophus* have the single median process at the anterior end much better developed than has been observed in any *Bibio* pupa.

### *References to Literature.*

Several references to damage caused by *Dilophus* larvae to crops have been noticed previously. The following additional references may be mentioned :—

Cameron, A. E. (1913). "General Survey of the Insect Fauna of the Soil." *Journ. Econ. Biol.* viii, 3.

Curtis, J. (1844). "Dilophus febrilis." *Gardeners' Chronicle.*

Morris, H. M. (1917). "The larval and pupal stages of *Bibio johannis*, L." *Ann. App. Biol.* iv, 3, pp. 91–114.

Morris, H. M. (1921). "The larval and pupal stages of the Bibionidae." *Bull. Ent. Res.* xii, 3, pp. 221–232.

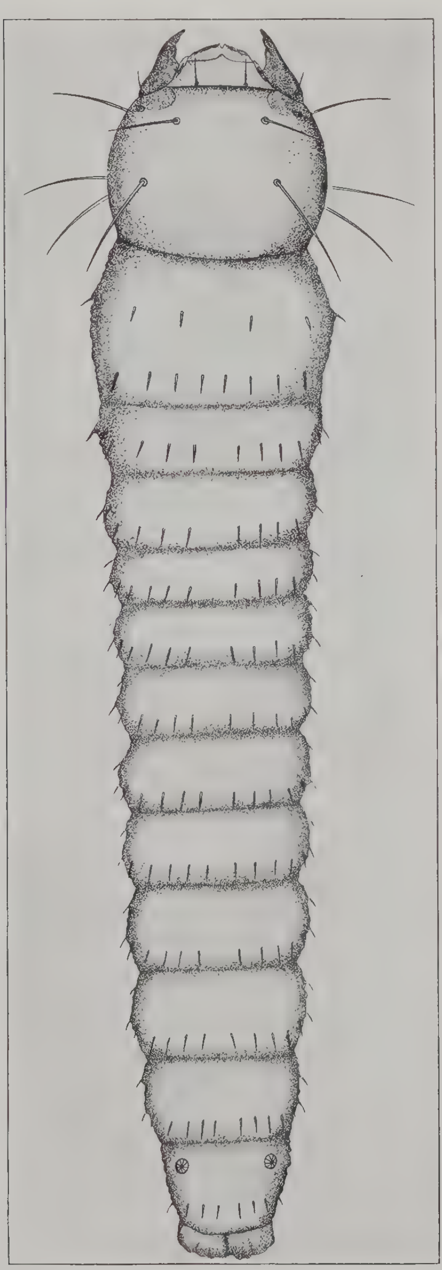

Fig. 1. Newly hatched larva of *Dilophus febrilis*, L.

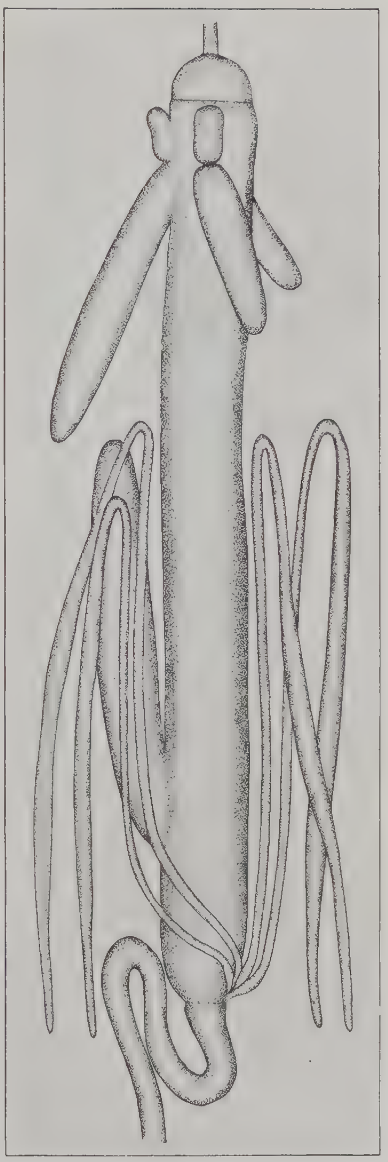

Fig. 2. Alimentary canal of larva of *Dilophus febrilis* L., lateral view.

# ON A METHOD OF SEPARATING INSECTS AND OTHER ARTHROPODS FROM SOIL.

By Hubert M. Morris, M.Sc., F.E.S.

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In an investigation of the insect fauna of the soil, the obtaining of the insects from this medium has hitherto been a very laborious and tedious process. It has

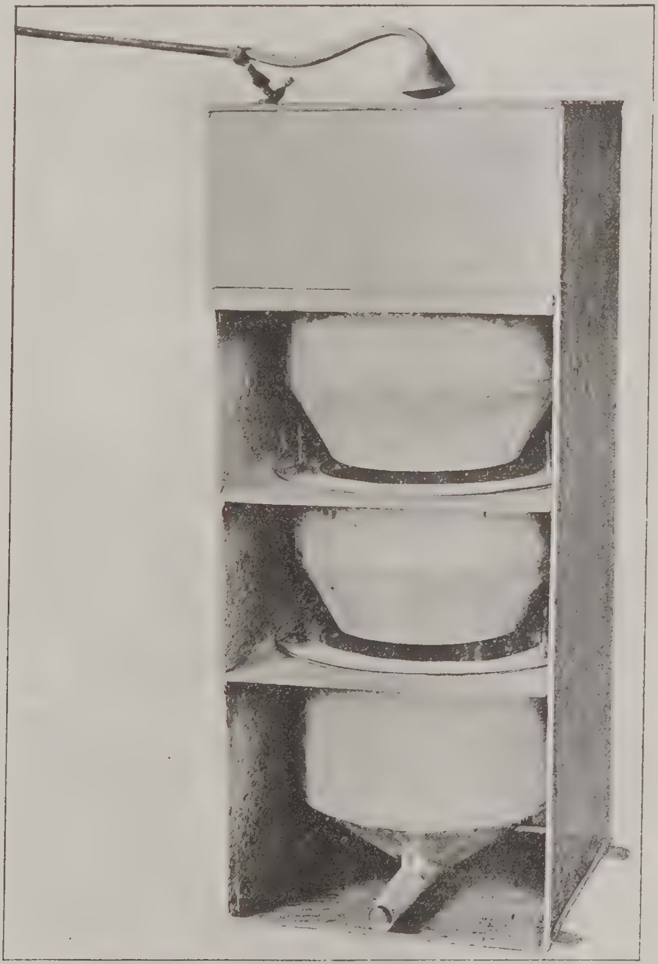


Fig. 1. Apparatus for obtaining insects, etc., from soil; $\times \frac{1}{9}$.

necessitated the crumbling of the soil by hand, and the examination of it in small quantities at a time over sheets of paper. This method is naturally a lengthy one, and in order to facilitate it the apparatus which is now described was designed.

By means of this device the soil is washed through a series of sieves with meshes of decreasing size. The mesh of the final sieve is small enough to retain either all the insects or all but the most minute, while at the same time allowing the finest soil particles to be washed away.

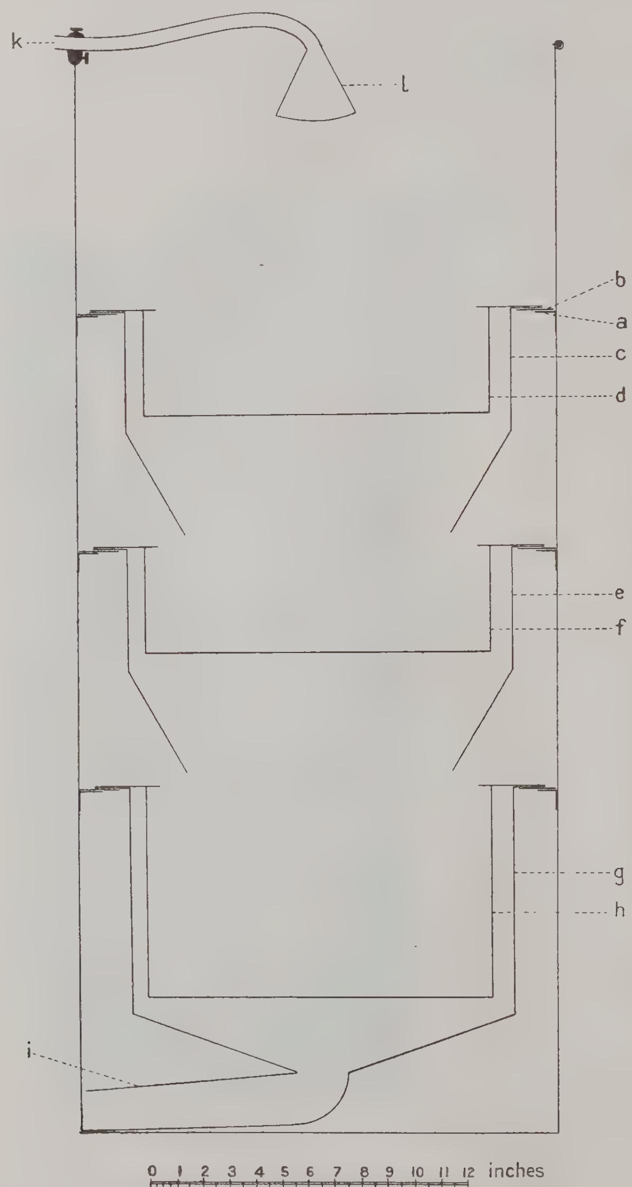



Fig. 2. Median vertical section of apparatus: *a*, ledge; *b*, shelf; *c*, first funnel; *d*, first sieve, with holes 3·5 mm. in diameter; *e*, second funnel; *f*, second sieve, with holes 1·5 mm. in diameter; *g*, third funnel; *h*, third sieve, with 50 meshes to the inch; *i*, outlet for water; *k*, pipe connected to water supply; *l*, rose.

The apparatus consists of an outer case of galvanised iron, supporting three sieves. The outer case is 41 in. high, and 18 in. square inside. One side and both ends of the case are open, except for 9 in. at the upper end of the open side (fig. 1). At distances of 10 in., 19 in. and 28 in. respectively from the top, pieces $\frac{3}{4}$ in. wide are fastened inside round the three sides of the case, forming ledges (fig. 2, *a*) on which slide the shelf-pieces described later. The case is strengthened round the top and bottom and along the two free sides by having the edge turned over stout wire.

There are three shelf-pieces (fig. 2, *b*), made to slide on the ledges described above, each $18 \times 18$ in., the upper one having one inch turned up on its outer side to prevent water splashing out there. Each shelf has a circular hole in it, 15 in. in diameter.

Passing through the hole in each shelf, and supported on the shelf by a rim $1\frac{1}{4}$ in. wide is a funnel, $14\frac{1}{2}$ in. in diameter. Two of these funnels are alike (fig. 2, *c*, *e*), and the third is larger (fig. 2, *g*). The two smaller funnels have sides which are straight for $4\frac{1}{2}$ in., and then converge for another $4\frac{1}{2}$ in., the diameter of the opening at the bottom being 10 in. The third funnel is of the same diameter as the other two, but the straight sides are $8\frac{1}{2}$ in. long, and the lower part converges to a hole 2 in. in diameter, to which is fastened a pipe that narrows down to a diameter of $1\frac{1}{2}$ in., and acts as outlet for the water (fig. 2, *i*), being long enough to carry the water clear of the case.

The object of these funnels is to avoid loss of water as the water passes from one sieve to the next below, and they are necessary owing to the sieves being perforated at the side as well as at the bottom.

Two of the sieves are equal in size and the other larger, corresponding to the three funnels into which they fit. Two of the sieves are 13 in. in diameter and 4 in. deep (fig. 2, *d*, *f*), while the third is of the same diameter but 8 in. deep (fig. 2, *h*). Each sieve has a rim which projects 2 in. on the outside, to support the sieve in the funnel, and the rim also projects $\frac{1}{2}$ in. on the inside to prevent insects from crawling out and so being lost. To the rim is fastened in each case a pair of handles of convenient size, to facilitate moving the sieves when they are full of soil.

Each of the sieves is strengthened by cross-pieces of stout wire on the outside of the bottom, and in addition, in the case of the deepest sieve, by a piece of wire round the outside at 4 in. from the bottom. The two smaller sieves are made of perforated zinc with round holes 3·5 mm. and 1·5 mm. in diameter respectively, and the large sieve is made of brass wire gauze with 50 meshes to the linear inch. Both the sides and bottoms of the sieves are made of these materials in order to avoid danger of the sieves overflowing owing to the choking of the holes by soil particles. All other parts are made of galvanised iron.

A lead pipe, $\frac{1}{2}$ in. in diameter, to one end of which is attached a large rose, is clamped to the upper edge of the case, the other end of the pipe (fig. 2, *k*) being connected with the water supply. The rose (fig. 2, *l*) is 3 in. in diameter and has 34 holes, each about $\frac{1}{16}$ in. in diameter. The face of the rose is convex, so that the jets from the holes diverge, forming a cone. The rose is so arranged that when the water is turned on the spray from it spreads sufficiently to cover the bottom of the first sieve, the water striking the soil with sufficient force to assist considerably in breaking it down.

In use, the sieve with the largest mesh is placed in the upper position, that with the smallest mesh in the lowest, and the one of intermediate mesh in the middle. The soil to be examined is placed in the upper sieve, the water turned on, and the soil is then washed into three lots on the sieves, the finest particles being carried away with the waste water.

The water is allowed to run until it passes through clear, all the sieves being stirred occasionally, and the upper sieves are removed when the stones in them are washed clean, so that the finer particles in the lowest sieve may be more thoroughly washed.

In dealing with a turf, it is broken up into small pieces before the water is turned on. Material of this kind requires longer to wash than arable soil, and the plants require examination after the soil has been removed.

The first sieve, with a mesh 3·5 mm. in diameter, retains the stones from the soil and only very large insects; the second sieve, with a mesh of 1·5 mm., retains the smaller stones and large insects, and the third, with 50 meshes to the inch, retains the coarse sand and the remaining insects. The residue on each sieve has to be examined for insects, that on the first and second being quickly done, as only the largest insects would be retained by them. The residue on the third sieve has to be very carefully examined, as most of the insects are found in it. This can be done by drying the sand and then examining it, or it may be done by taking the sand in small portions in a basin of water. As the clay has all been washed away, the water is quite clear in a few seconds, and many of the insects, such as Collembola and most adult forms, float on the surface, while those that sink can be readily seen, as they tend to lie on the surface of the sand at the bottom of the basin.

The sieves were made of the sizes given above in order to wash about 12 lb. of soil at a time, but up to 14 or 15 lb. of soil could be dealt with by these sieves. It is found with Rothamsted soil that the water has to run for about 40 minutes to remove all the clay from this quantity of soil, the washing being much accelerated by occasional stirring.

It was considered advisable to have three sieves in the present instance owing to the large number of stones in the soil of this district, but in a less stony district the upper sieve might possibly be dispensed with, or one with perforations of intermediate diameter might be substituted for the upper two. Gauze with 50 meshes to the inch was considered most suitable for the lowest sieve, as a finer mesh increases the quantity of soil that is retained, while a larger mesh would allow many of the smaller insects to be washed away.

Possibly the two lower sieves need not have been quite so deep, but it was considered advisable not to run any risk of the water overflowing, as if it did so some of the insects might be carried away by it. If the insects are subjected to the washing for too long a time it is possible that they would be injured, but after the time mentioned above, 40 minutes, they seem to be little affected.

Various other methods of treating the soil have been tried, in the hope of finding a method by which it would be possible to remove the insects completely from the soil, but it has not been found possible to do so owing to the variation in size and specific gravity of the insects. By the method described above the volume of soil requiring careful examination is reduced to a minimum, and as this portion consists of clean sand it is much easier to examine than an equal quantity of clayey soil.

The use of liquids of different specific gravities was also considered, but it was not thought to be a suitable method, owing to the quantity of the liquid which would be required; its possible injurious effect on larvae, some of which it is desirable to obtain alive; and the variation in the specific gravity of the insects.

# A NEW HYMENOPTEROUS PARASITE OF THE AUSTRALIAN FERN WEEVIL, *SYAGRIUS FULVITARSIS*, PASC.

By D. T. Fullaway.

**Ischiogonus syagrii,** sp. n.

Female. Long, 3·75 mm. Ochraceous (brown ochre, Winsor & Newton), the eyes, antennae outwardly, tips of mandibles, ocellar space, prosternum anteriorly and a thin line on either side on the groove of the notum, a large spot anteriorly on the mesopleurae, distal tarsal segment and the sheath of the ovipositor black. More or less thinly clothed with hair.

Head cubical, slightly convex, temples rounded, face somewhat retracted, cheeks polished, fairly wide, eyes bulging slightly, ocelli arranged in an equilateral triangle on the vertex, the members about one diameter apart and four from the border of the eye; antennae placed on a slight ridge at the junction of the front and top of the head, in circular sockets equidistant from each other and from border of eye, filiform, as long as the body, with 28–31 segments, scape and pedicel stouter than the segments composing the flagellum; mandibles short, stout, curved, acutely pointed at apex. Thorax rugoso-punctate; pronotum and pleurae concave medially, the concavity costate; prosternum smoother; mesonotum finely punctate, tri-lobed, the lobes slightly convex, parapsidal furrows widely separated and fairly deep in front, converging posteriorly where they merge into a broad shallow depression; mesopleurae below and mesosternum more finely punctate, smooth and shining, disc of the scutellum flat, keystone-shaped, smooth and finely punctate, two oval foveae at base; metanotum convex, rugose, biareolate basally, the areolae large extending more than half the length and finely rugulose. Abdomen elongate ovate, 1st segment a little longer than apically wide, the 2nd twice as wide as long, the remainder transverse, tergites of 1st and 2nd longitudinally striate, 3rd and 4th with short striae in a transverse furrow behind the anterior margin widening laterally, the remaining surface smooth and polished, each segment behind the 2nd bearing a transverse fascia of hairs, ovipositor not quite as long as the abdomen and hairy. Legs slender. Wings infuscate, long and narrow, stigma lanceolate, yellowish brown, first abscissa of radius a trifle more than half the length of second, second cubital cell nearly twice as long as wide and parallel-sided, recurrent nervure entering first cubital cell, nervellus post-furcal, subdiscoidal joining the discoidal below the middle; submedian cell of hind wings less than half the length of median, transverso-medial nervure nearly reaching hind margin.

The male is smaller in size and has the abdomen more slender.

Described from two females and two males (type, allotype and paratypes in the collection of the H.S.P.A. Exp. Sta., Honolulu) reared on the larvae of *Syagrius fulvitarsis*, Pasc., at Nimbin, New South Wales, by C. E. Pemberton, April–May 1921.

# ON FISH AND MOSQUITOS IN PALESTINE.

By P. A. Buxton, M.R.C.S., L.R.C.P., D.T.M.&H.,

*Fellow of Trinity College, Cambridge; Government Laboratory, Jerusalem, Palestine.*

One of the greatest difficulties of anti-mosquito work in Palestine is that there are a series of swamps in the littoral plain, lying almost at sea level and prevented from draining into the Mediterranean by sand-dunes and sand-bars which block their outlet channels. It appears that cutting channels through the coastal dunes is a task which would have to be repeated at very frequent intervals, and until somewhat large sums of money are available the pumping of these numerous swamps into the sea cannot be undertaken. There are, moreover, other rather large areas of marsh, notably Lake Huleh, Beisan marsh and the Marj Sanour, the proper drainage of which is at the moment beyond the financial resources of the country. We have therefore to rely for the moment on ameliorative measures which are admittedly not sufficiently radical. Among other things, I have begun a study of our native fish, hoping to find some small and voracious species that breeds rapidly and is able to live in waters of different degrees of salinity. The results which I have obtained are perhaps discouraging, but certainly interesting.

The problem is essentially one of oecology; we must study the mosquito larvae and fish in their natural environment, and endeavour to find out whether they are in any way dependent one on the other. If we have reason to hope that a particular species of fish occasionally takes mosquito larvae, then any information about its food in a state of nature is relevant. It appears to me that no laboratory experiment is valid in elucidating a problem such as this; the conditions of experiment can never adequately reproduce the complex conditions which prevail in the marsh. I have therefore confined myself to examining the guts of fish caught in their natural home and preserved by being put instantly into 70 per cent. alcohol, or 4 per cent. formaldehyde; and I may remark in passing that this method of preservation is adequate for fish up to 3–4 in. long. Penetration of the formalin or alcohol is so quick and good that I have been able to observe the nuclear characteristics of Vorticellids in a *Cyprinodon* which has been preserved for several months. Specimens of all species of fish examined have been determined by Mr. C. Tate Regan, F.R.S. The results obtained are as follows:—

1. Young *Mugil* sp. (family Mugilidae), 2 in. long, from the Kishon marshes, July; 11 dissected. None contained any animal matter of any sort. They were packed with diatoms, and had also taken other unicellular algae, Volvocales, Dinoflagellates and grit.

2. *Tilapia zillii* (family Cichlidae), specimens from 1–4 in. long, from the Kishon marshes, July; Nahr Barideh, Jaffa, December; and Beisan, June. In each case fish came from water in which mosquito larvae could be found, though generally the larvae were well protected in shallow bays or among dense weeds. The following were found in 31 stomachs and intestines examined: in every individual diatoms and grit and Copepods; in 21 individuals, filamentous algae; in 10 individuals, Volvocales; in 2 or 3 individuals, Ostracods, Vorticellids, jumping Rotifers, pieces of grass, small Nematocerous larvae, and undetermined insects; in single individuals, Cladocera, adult *Leptoconops* (Chironomidae), beetle larvae, and Hydrachnids. To summarise these results one may say that *Tilapia zillii* takes a wide range of food, animal and vegetable, but that we have at present no record of mosquito larvae being found in its alimentary canal. I understand from Dr. L. H. Gough that in Egypt a species of *Tilapia* locally known as "Bolte" has been distributed as a mosquito destroyer, and that its introduction has been followed by a reduction in the number of mosquitos and of cases of malaria in certain areas.

3. *Cyprinodon* spp. (family CYPRINODONTIDAE). Eleven specimens of *C. calaritanus*, Kishon marshes, July; 21 specimens of *C. sophiae*, Beisan, March and June; 35 specimens of *C. fasciatus*, Beisan, March and June. As the feeding habits of these three species seem to be very similar I shall deal collectively with the results of dissection of the 67 specimens. I found filamentous algae in 42 individuals; diatoms in 35; Cladocera, Ostracoda and small Nematocerous larvae in 25–30; large quantities of fine grit in 18; Copepods in 12; small Nematocerous pupae or small beetle larvae in 8; insect remains in 7; small adult Nematocera in 6; adult Mymarids in 5; adult thrips in 3; snails or small adult calyptrate Diptera in 2; and the following only in one fish each, water-boatman, Hydrachnid, minute dragonfly larvae, *Difflugia* and fish eggs. The small Nematocerous larvae have been identified by Mr. F. W. Edwards as almost certainly those of a species of *Corynoneura* (CHIRONOMINAE), or possibly *Leptoconops*. The small pupae are probably the same, as larvae and pupae were often found in the same fish. It is remarkable that if half a dozen *Cyprinodon* of one species are caught at the same time and place and examined, one will be found crammed with Copepods, another with Nematocerous larvae, another with filamentous algae and diatoms and another with grit. It appears that individuals prefer to make a meal completely from one type of food. The conclusion I draw is that *Cyprinodon* is almost omnivorous and will eat anything which is in season; the small Crustacea (Copepods, Ostracods and Cladocera) are much more abundant in spring than in summer, and accordingly are common constituents of the fish's diet only in spring. On the other hand, winged insects, such as Mymarids, water-boatmen, adult Diptera and thrips, are much more commonly found in summer than winter. Further *Cyprinodon* takes its food at all levels; the Ostracods and *Corynoneura* (?) larvae from the bottom; the Copepods and Cladocera probably from midwater; the majority of the winged insects either floating on the surface, or flying above it. This catholicity of taste and variety in methods of taking food are points in favour of *Cyprinodon*, because they must enable it to continue to exist in water in spite of changing conditions. It appears that *Cyprinodon* is resistant to considerable changes in the salinity of the water in which it is living, though I have no detailed observations on this point. Certainly it thrives all through the summer in shallow marshes which are rapidly diminishing in size, and it is known that some of the species live in hot springs. It is disappointing that we have obtained no definite evidence of its taking mosquito larvae.

It appears unlikely that we shall find any other more suitable fish among our native species. There are small members of the genera *Barbus*, *Cobites* and *Blennius*, but probably they are bottom-feeders, and not sufficiently active and voracious for our purpose.

So much for the result of dissection: we have failed to find Culicid larvae in any of the fish dissected. The results of field observations are more encouraging. In the marshes at the mouth of the river Kishon, in July 1921, *Ochlerotatus caspius* was breeding in the greatest profusion in isolated cows' footprints among the *Juncus*; wherever the footprint was connected by water with the main body of the marsh no larvae could be found; they were also absent from the shallows of the marsh itself. This I attributed to the fact that *Cyprinodon calaritanus* and young *Tilapia zillii* swarmed in all shallow places. At the same time larvae of *Anopheles* were quite common in floating vegetation in the marsh. At Beisan, in June 1922, the larvae of *Culex perexiguus* and *O. caspius* were most markedly confined to footprints and other small collections of water to which *Cyprinodon sophiae* and *C. fasciatus* had no access. In the larger bodies of water Culicine larvae could never be found at all, but larvae of *Anopheles hyrcanus* (*sinensis*) were quite numerous in patches of green algae, which appeared to protect them from the *Cyprinodon*.

# THE LIFE-HISTORY OF THE AUSTRALIAN MOTH-LACEWING, *ITHONE FUSCA*, NEWMAN (ORDER NEUROPTERA PLANIPENNIA).

By R. J. TILLYARD, M.A., Sc.D. (Cantab.), D.Sc. (Sydney), C.M.Z.S., F.L.S., F.E.S.,
*Entomologist and Chief of the Biological Department, Cawthron Institute, Nelson, N.Z.*

(Plates IV & V.)

In a previous publication (1919), I brought our knowledge of the ITHONIDAE up to date, so far as the perfect insects were concerned, and gave a short account of the work which had been done by Mr. Luke Gallard and myself in discovering the habitats and dates of appearance of the commonest species, *Ithone fusca*, Newman. This paper also recorded our success, in November 1918, in obtaining numbers of fertile eggs, larvae and pupae. I promised then to give a full account of the life-history in a later paper, and that promise is now being fulfilled.

The study of the life-history, begun in 1918, was continued in 1919 when I paid a visit to Jervis Bay from 8th to 22nd September, spending most of the time digging the sandy soil around the Naval College in a search for larvae and pupae. The result of eight days' digging, in which several members of the Naval College staff most cheerfully joined, was a total of 21 larvae in various stages of growth, and 15 cocoons containing larvae or newly-formed pupae. The same year Mr. Gallard continued his investigations at Woy Woy and Epping, finding a number of larvae in all stages of growth.

Nothing was done in 1920, as I was absent from Australia; but in October of last year I again visited Sydney, and a fortnight was spent on the same ground where the larvae were originally discovered in 1918. On this occasion there were with me, besides Mr. Gallard, M. André Tonnoir, the well-known Dipterist of Brussels, and Mr. A. J. Nicholson, the newly-appointed Lecturer in Entomology at Sydney University. During the fortnight 30th October to 12th November, a large number of adult *Ithone* were taken and paired in special cages, about 7,000 fertile eggs being obtained from them. Of these, about 5,000 were sent across to New Zealand, 1,000 to America, and nearly a thousand were fixed at various stages of development for future embryological studies. Digging was also carried out for the larvae, and a considerable number obtained, although it was too late in the season for most of them. The most successful day was 8th November, when, as a result of a few hours' digging round a single *Eucalyptus* tree by Mr. Nicholson and myself, no less than 57 larvae in different stages of growth were obtained, together with a representative collection of the various Coleopterous larvae found in the same soil, on which the *Ithone* larvae prey. A special study was also made of the habits of the imago, and their rapid destruction by hosts of enemies.

Before beginning the actual account of the life-history of this remarkable insect, it will be of interest to show how it came about that the larva was at last discovered after some years of fruitless endeavour. In September 1915, I discovered the species *Heterithone fulva*, Till., on Stradbroke Island, and noticed a number of them drowned in two large water-tanks. Coupling this with the close similarity of the insects to the Megaloptera, it appeared likely that the larva would be either aquatic or sub-aquatic. As a result, both Mr. Gallard and myself searched chiefly, during the following two years, in lagoons and moist places, without any success. In October 1917, Mr. Gallard was staying with his family in Mr. Hansford's cottage at Ocean Beach, near Woy Woy, when Mrs. Gallard discovered one evening a fine *Ithone fusca* sitting on a fence-post. The soil was sandy, with no fresh-water creek or lagoon within a mile or more. In a few days, Mr. Gallard had found about two dozen of the insects, mostly hiding in an outhouse near the cottage. We therefore concluded that it was likely that the larvae lived in the sandy soil; and we proceeded, during November

and December of that year, to pay a series of visits to this locality, digging up the ground all round the cottage, and especially in the vicinity of the outhouse and around a number of trees near by. We found a number of rather large cocoons made of sand; but from these there emerged a very common Noctuid moth, whose caterpillars we also sometimes found at the bases of tree-trunks. The only other insects in the soil appeared to be various larvae of Diptera, Brachycera, some cocoons of Thynnid wasps, and a number of different species of Coleopterous larvae of the family SCARABAEIDAE. It never occurred to either of us that one of these apparently Scarabaeid larvae was in reality the unknown larva of *Ithone*, and we certainly dug up and threw aside quite a number of them, so set were our minds on finding a larva which would conform to the primitive Planipennian type, as exhibited by the PSYCHOPSIDAE or HEMEROBIIDAE. But in 1918, when we succeeded in pairing the adults, it was with the greatest astonishment that we saw emerging from the fertile eggs a number of tiny white melolonthoid grubs. On making an enlarged drawing of one of these under the camera lucida, it was at once seen that the larva of *Ithone* was a soft-bodied, burrowing insect, closely similar to a Scarabaeid larva in general appearance. We were then able to recall at once the particular grub which we had dug up time and again, and thrown away, but which, it now appeared, was in reality the prize we had been searching for.

From that time on, larvae were easily obtained, and we soon found that they could be distinguished from all the true Scarabaeid larvae, not only by their detailed structure, but especially by a very strong odour of citronella which they gave out, and which frequently arose from the soil while we were digging; when this odour was noticed we were sure to get a larva of *Ithone* in the next spadeful or two of soil.

A further pitfall awaited us through the chance happening that the first pupa discovered was lying free in the soil. Again, the similarity of *Ithone* to the Megaloptera occurred to my mind; and as the pupa was elongated, not curved round like those Planipennian pupae which are enclosed in cocoons, I took it as proof that the larva did not spin a cocoon, and said so in my previous paper (1919, p. 416). However, Mr. Gallard and myself almost simultaneously discovered, shortly afterwards, the cocoon of *Ithone* with the larva inside it, so that I was able to correct this mistake by a postscript in the same paper (p. 437).

The outline of the life-history was now complete, and it only remained to observe the larvae in captivity, study their feeding habits, their methods of burrowing and progression, the spinning of the cocoon, and the emergence of the imago from it. The discovery of the pupa free from the cocoon, in the soil, was explained when we found that the pupa cuts its way out of the cocoon by means of its huge mandibles, and travels some way in the soil before disclosing the imago.

I should like here to put on record the large share that Mr. Gallard deserves of the credit for the discovery and working out of this life-history. He has been most enthusiastic in the work, and has at all times taken upon himself the giant's share of the heavy labour of digging the soil, without which no larvae could have been obtained. My best thanks are due to him for the very great assistance he has given me. I also wish to thank Mr. W. C. Davies, Curator of the Cawthron Institute, for the excellent photographs which he has taken of the various stages of the life-history; these have been collected together and are reproduced on Plate iv. The text-figures have been prepared by myself, with the aid of an Abbé camera lucida.

### The Life-Cycle of *Ithone fusca*.

The complete life-cycle of *Ithone fusca* appears generally to last exactly two years. When digging the soil during the first two weeks in November, which is the period during which the imagines are on the wing, we found plenty of larvae, but no pupae. Most of these larvae were from half- to three-quarters grown. As there is no record of a second brood, these larvae must last through a second summer, and

would not become adults until the following November. Nevertheless, as with other Planipennia, it is probable that some, if food were abundant enough, might complete their life-cycle in one year, while others, when food is scarce owing to drought, may take three years to reach maturity.

The life-cycle is made up as follows, taking as an example an egg laid on 1st November :—

| *Stage.* | *Dates.* | *Duration.* |
|---|---|---|
| Egg .. .. | .. 1st Nov.–2nd Dec. | .. 31 days (average). |
| Larva (five instars) | .. 2nd Dec.–14th Sept. | .. 1 year 9½ months (average). |
| Larva in cocoon | .. 14th Sept.–7th Oct. | .. About three weeks. |
| Pupa in cocoon | .. 7th Oct.–31st Oct. | .. About three weeks. |
| Imago .. .. | .. 31st Oct.–2nd Nov. | .. Two or three days. |

The above are all given as average periods. The eggs may hatch a little sooner if the weather is very hot during the embryonic period, or they may be a little retarded if the weather becomes cold. The female imago usually pairs within an hour or two of emergence, and most of its eggs are laid the same night; she seldom lives more than two days. The male also seldom lives more than two or three days, though I have succeeded in keeping them alive for a week. They take no food in the natural state, though their mouth-parts are well developed.

No definite times can be given for the separate larval instars, as ecdysis depends entirely upon the amount of growth, and this in turn is dependent upon the amount of food taken. One or two good meals are enough to enable the larva to grow to its full size for any given instar, but many days may pass during which the larva is burrowing in the ground without finding any food at all. Consequently, in any given brood there are always some larvae which grow much faster than the rest, and there are also others which, finding no food at all, die at last from sheer exhaustion.

**Emergence of the Imago.**

The adult *Ithone fusca* emerges just about sundown during the fortnight from the end of October to the middle of November. The pupa discloses the imago while still in the soil; the imago crawls out with its wings still unexpanded, and makes for the nearest post or tree-trunk, up which it climbs to a height of from one to three feet. Its wings expand so rapidly that they are generally fully formed by the time the insect has come to rest. They are held outwards away from the body during expansion, and are then folded down in a somewhat flattened, roof-wise manner. It is very curious to be watching a clear patch of sandy soil and to see, quite suddenly, a slight falling in of the sand, so that a small pit is temporarily formed, from the middle of which there emerges an adult *Ithone*, scurrying off almost like a cockroach to find a suitable perch to rest and expand its wings.

As soon as the sun is set, the moth-lacewings begin to vibrate their wings very slightly but rapidly, and then take flight. The females, which are always much less in number than the males, fly rapidly like ghosts across the bracken and herbage, and settle upon some convenient tree-trunk. The males dash hither and thither exactly like Hepialid moths, and soon begin to assemble in swarms around the females. While on the tree-trunks they will often rush about and circle round and round, while at other times they will sit at short distances apart, rapidly vibrating their wings, ready to dash off again at a moment's notice.

Calm evenings or those with a light north-east wind were those which favoured the swarming of *Ithone*. On nights with a cold south or south-east wind, there was little or no emergence. Most of the insects selected the west or north-west side of the trees, this being the warmest and most sheltered. The largest swarm I noticed was on a trunk where three females had settled close together. Around these were swarming more than a hundred males. While bottling them and sweeping them

into my net they ran all over me like cockroaches, getting down my neck and up the sleeves of my coat. A single female may have anything from four or five up to more than 50 males around her.

Pairing takes place very rapidly, the male sidling up to the female, and the latter raising her wings slightly on one side, so that the male may come closer. They then remain alongside one another, the male seizing the curved end of the female in his claspers. In captivity, the act of pairing sometimes lasted a considerable time, up to half an hour, but under natural conditions it appears to be much quicker, probably because of attacks from a multitude of enemies.

**Enemies of** *Ithone*.

On a favourable night, when *Ithone* may be expected to swarm, the whole of the life of the bush seems to be getting ready for the event. We could see huge spiders spinning their tough webs everywhere, in feverish haste ; while battalions of ants of various kinds, especially Bulldogs (*Myrmecia*), Mound ants (*Iridomyrmex detectus*) and Greenheads (*Ectatomma*), began to swarm up the trees and take up expectant attitudes, waiting to pounce upon their victims. Huge Lycosid spiders, commonly called "triantelopes," came out from their lairs, also ready to pounce ; and even frogs took up suitable positions at the bases of the tree-trunks.

Immediately the swarm begins *Ithone* falls a victim to its enemies in hundreds. Approaching my first tree, I saw four male *Ithone* struggling wildly, each in the grip of from eight to ten savage Greenheads, which had already bitten off most of their wings. On the next tree a male *Ithone* was struggling in the grip of a large spider ; on returning later, I found that all except part of its wings had been devoured. A little further on, some Bulldog ants had seized a couple of victims ; while in various places they could be seen struggling in the broad spiders' webs stretched from bush to bush. It was often a race between myself and these numerous enemies, to see who could secure the *Ithone* first. I should estimate that less than half of the swarm survives the first *mauvais quart d'heure*. In the early morning, the Thickhead and other birds are abroad hunting down the remainder, so that by 8 a.m. little of the previous night's swarm is left.

The actual flight of *Ithone* lasts under an hour, and it is necessary to search thoroughly for females while they are about, the males being so abundant that one could easily secure 50 or so without getting a single female. By the time darkness has set in the flight is finished, and from then onwards only occasional specimens are to be got, either resting on trees, running about on the ground, or sometimes coming to light.

**Oviposition.**

The female, when about to oviposit, runs about on the ground until she finds a suitable place where the soil is soft enough. She then proceeds to work her abdomen down into the soft soil, using all the time her peculiar sand-plough for digging it up, until her wings come to lie almost flat on the surface, and her legs sprawl out in front of her. In this position, she works her abdomen first vertically downwards and then somewhat forwards, so that its apex is from one-half to three-quarters of an inch below the surface. She now lays her eggs steadily, working hard all the time and rolling each egg separately in the sand, which adheres to its sticky surface so as to form a protective covering. In captivity large Mason jars were used, in which we placed an inch or more of sandy soil. Sometimes the females would work down to the glass bottom, and in such cases a number of the eggs would become glued to it, and could not be removed without damage.

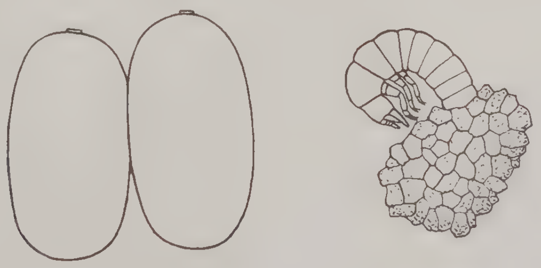
The sand sticks so tightly to the egg that when I first tried fixing them in Bouin's fluid I was quite unable to remove it, even after weeks of immersion in the fixative. This difficulty was overcome last year by giving some of the females sugar, instead

of sand, in which to oviposit. Eggs were laid freely in the sugar, but the latter did not stick to them. Owing to their white colour, they could not be easily seen. I therefore dissolved the sugar, spoonful by spoonful, in water, when the eggs would float up, and could be taken out by means of a brush and placed on strips of paper, to which they adhered slightly. A number of these were kept for a month, to see whether this treatment had caused any damage; but they all hatched out quite safely.

The number of eggs laid by a single female varies from about 200 to close on 300. From 2nd to 6th November 1918, I counted the eggs laid by one female each night. Each of these five females was exhausted after one night's work, and did not lay any more eggs the following day. The counts were 195, 206, 253, 242 and 289 respectively; the last female was exceptionally large. This gives a total of 1,185 eggs from five females, or an average of 237. Each female worked steadily for some hours, until quite exhausted; so that it would appear to take over one minute to lay each egg and roll it thoroughly in the sand.

**The Egg** (text-fig. 1).

The eggs are of a creamy white colour and somewhat soft consistency, in shape broadly oval with slightly flattened ends; length, 1·7 mm.; transverse diameter, 0·9 mm. The micropyle is situated at the anterior end, and consists of a minute slightly raised disc-like projection, as shown in text fig. 1*a*. The surface is quite smooth, without any sculpture whatever.



***a***. ***b***.

Fig. 1. *Ithone fusca*, Newm.: *a*, two eggs (× 20) showing micropyles; *b*, larva hatching from egg (× 11).

When sifted out from the sand in which they have been laid, the eggs are found in the form of small sand cocoons, mostly of oval shape, but sometimes quite irregular, owing to the adhesion of one or more larger particles of the soil. Their general appearance can be gathered from text-fig. 1*b*. If put away in a dry pill box, without either soil or moisture, they hatch quite readily. The embryonic period lasts about one calendar month. The emerging larva makes a hole in one side of the egg, not far from the end, and comes out head first, curving over on itself ventrally as it emerges. When its head, thorax, legs and about six abdominal segments are free, it rests for a short time in the position shown in text-fig. 1*b*. Finally it struggles free from the egg-shell and at once begins to burrow down into the soil.

**The Larva.**

Owing to the fineness of the larval exuviae or pellicles, it has not been possible to observe the actual series of ecdyses of the larvae. This in any case would be most difficult to do, as they all take place deep in the soil. Also, as great changes in size occur, not only during the course of a single ecdysis, but also in the comparative

sizes of different individuals during the same ecdysis, I have had to determine the number of instars by morphological methods. I found that measurements of any sort were not to be relied upon, as this larva is so soft-skinned that even the prothorax and the back part of the head swells during the progress of each ecdysis. The only safe method seems to be a careful study of the chaetotaxy and of the form of the spiracles. By making careful preparations of a number of larvae of all sizes in caustic potash, I have been able to determine that there are certainly *five* instars. This is remarkable, since all other Planipennia have only three or four. The changes in the general shape of the larva, the form of the head, prothorax and legs, the form of the mouth-parts and antennae, are all so slight as to be practically useless in this connection. As regards the spiracles, these are circular in the newly-hatched larva. During each instar, they become more and more oval; until, in the last larval instar, the whole series is of a very elongate oval shape, as shown in Plate iv, fig. 7. Correlated with the changes in the form of the spiracles is a much more definite change in the chaetotaxy. The newly hatched larva possesses, with the exception of the specialised end-segments of the abdomen, only long slender *primary setae* (macrotrichia) and an abundant armature of minute microtrichia also. At the second instar, a number of *secondary setae* of macrotrichial type, but smaller than the primary setae, occur; these increase rapidly in number with each instar, until they completely hide the original primary setae, which can only be found for certain in one or two special areas where the differentiation of the two types of setae remains marked.

For the determination of the correct instar, I found the metathorax the most useful segment. It has the double advantage of having a chaetotaxy closely comparable with that of an abdominal segment, and secondary setae formed on a short, rather stout model, quite unlike that of the primary ones. Consequently the primary setae can be picked out through all instars, and the invasion of the secondary setae on to the specialised clear areas, or *pinacula*, which originally carried certain groups of primary setae only, can be followed up with precision. On the abdominal segments, the secondary setae, though at first somewhat smaller than the primary, are of the same slender form, and by the third instar there is so little difference in size that the task of picking out the one from the other is quite hopeless.

A point of great interest in this larva is the fact that the primary setae can most certainly be homologised with those of the Lepidopterous larva, as I have also found to be the case with the larva of the Mecopteron *Chorista* (though this result has not yet been published). The attention of Lepidopterists is drawn to this fact, which emphasises, by a further striking character, the close affinity that I have already insisted upon as belonging to the whole of the Panorpoid Orders. It also throws some light upon the vexed question of the seta named *theta* in Fracker's nomenclature, which only occurs in the second instar of HEPIALIDAE, and is therefore considered as sub-primary by that author (1915, p. 34). This seta is absent throughout in *Ithone*, so that no evidence is forthcoming for its existence in the Planipennia. Its late arrival, therefore, in the Lepidoptera is probably due to its having been added to the original chaetotaxy after the definite evolution of the Lepidopterous larval type.

A short account will now be given of each larval instar, with special attention to the changes in spiracles and chaetotaxy.

**First Larval Instar** (Plate iv, fig. 2; text-figs. 2–5).

The newly hatched larva is actually about twice as long as the egg in which it was confined; though, owing to its curvature, it does not appear so long as this. The head and prothorax are of about equal size, and considerably larger than the other segments. The general form is melolonthoid; the larva is obviously adapted only for a burrowing existence, being very awkward and ungainly if placed on a flat surface. In attempting to walk, it keeps its abdomen arched, but presses its thorax down flat; in such an attitude, it can only make slow and very awkward progression.

But as soon as it is placed on loose soil, it begins to burrow with remarkable rapidity, passing the grains of sand backwards between its strong burrowing legs, so that its mode of progression much resembles that of climbing over a continuous succession of moving particles. It works steadily downwards through the top layer of dry soil, until it reaches the zone of slight moisture, where it passes its existence. During

Fig. 2. *Ithone fusca*, Newm., first larval instar, newly hatched, lateral view (× 40).

dry weather the larvae could be found from 18 in. to over 2 ft. below the surface ; but after rains they work upwards, always keeping close to the same zone of slight moisture, at about the same level as the Coleopterous larvae on which they prey. In exploring the soil for food, they often work spirally, turning round and round with a screw-like progression, and thus examining a very great volume of soil in a small space. As they are quite blind, and have excessively short antennae, it is doubtful by what sense they become aware of the presence of their prey, unless by actual contact. In this connection, we do not know for what purpose they emit the strong odour of citronella which is characteristic of them. It may possibly serve to prevent them from coming in contact with one another and so attacking one another in mistake for Coleopterous grubs.

The following is a detailed description of the newly hatched larva: *Head* moderately large, broader than long, somewhat narrower than the very wide prothorax. *Epicranium* smooth, shiny, cream-coloured, carrying about 11 setae on each side of the middle line. *Compound eyes* and *ocelli* entirely absent. *Antennae* very short, with only five segments, as shown in text-fig. 3*a* ; they are inserted on the epicranium somewhat behind and above the bases of the mandibles, with their bases wide apart. The basal segment is about as broad as long, the next somewhat shorter, the 3rd little more than half as long as broad, the 4th as long as the basal segment, slightly broader than the 3rd, the 5th a small knob seated on the apex of the 4th, and carrying four or five sensory setae ; there are also two or three longer tactile setae upon the 4th segment distally. These antennae are superficially like the labial palpi, but the latter have their bases very close together. Between and in front of the antennae the epicranium dips downwards as a narrow *frontal shelf*, separated from which by an indistinct suture is the *clypeo-labral plate*, which projects between the bases of the mandibles, with a nearly straight front edge, carrying four strong setae. The *mandibles* and *maxillae* are of the most extraordinary form, even for a Planipennian larva. In this Order, as is well known, the two pairs of jaws become highly specialised to form a pair of sucking-jaws on each side of the head,

the maxilla, or rather its galea (the palp and lacinia being absent) becoming an elongated lancet which slides to and fro beneath the somewhat more strongly built spear-like mandible ; the upper surface of the maxilla and the lower surface of the mandible are grooved, so that a complete tube is formed between them, and along this tube the juices of the victim are sucked by pharyngeal action. But in the larva of *Ithone*,

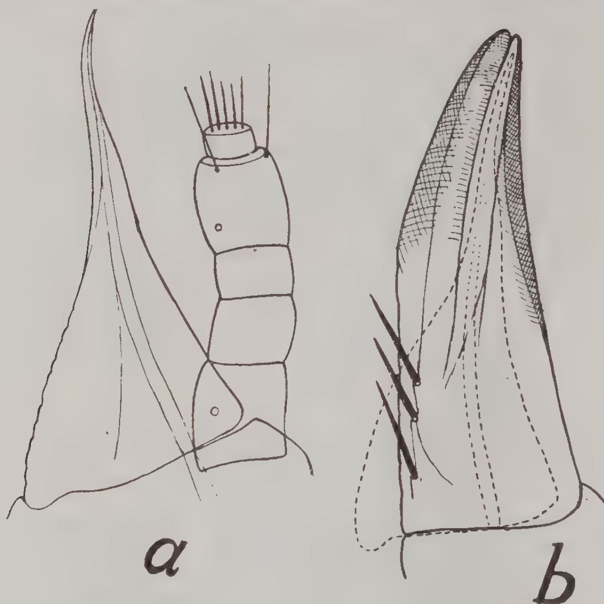


Fig. 3. *Ithone fusca*, Newm., first larval instar: *a*, left mandible and antenna; *b*, left maxilla, with the position of the mandible dotted in (× 180).

probably owing to the peculiar habit of always striking *upwards* at its victims, the functions of mandible and maxilla appear to be almost reversed, and their structure completely so. On first examining one of these larvae, one is struck by the fact that it is the *lower* jaw which is strongly chitinised, and which carries, on its upper surface, a deep groove in which the exceedingly slender apical part of the upper jaw works to and fro. The muscles of the mandible are weakly formed, and there is little sign left of the original ginglymus joint connecting it with the head ; on the other hand, the sides of the head below the bases of the maxillae are swollen out, and even become corrugated in the last instar, to accommodate the powerful muscles which work the maxillae themselves. It seemed to me at first probable that mandibles and maxillae had indeed changed places through some strange new conformation of the head ; but a number of careful dissections show that this is not so, for the mandibles can be clearly seen to be attached in their proper places close to and below the bases of the antennae, while the maxillae are always closely associated with the labium. Text-fig. 3*b* shows the slender mandible *in situ* in the groove of the stoutly built and strongly chitinised maxilla below it. The *mandible* itself (text-fig. 3*a*) is attached to the head by a very broad leaf-like base, and is somewhat triangular in shape ; the distal half is excessively slender, with the sharply pointed apex curving slightly inwards. A narrow groove runs from apex to base, on the underside. It is only heavily chitinised towards the apex and along the distal part of the two edges. The *maxilla* (text-fig. 3*b*) consists of a single strongly chitinised piece, probably the galea, inserted on a fairly broad base, which appears to represent the stipes and cardo

fused together. It is shaped rather like an elongated tooth, the outer edge being curved, the inner straight. The extreme tip is notched, forming the entrance to a deep groove, which can be traced with ease along most of its length. On the outer edge, near the base, three strong setae are developed. The labium (text-fig. 4) consists of a pair of four-segmented palpi with their bases set closely together on the

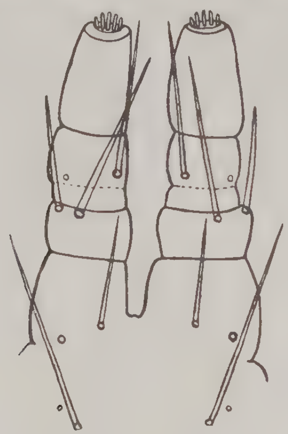


Fig. 4. *Ithone fusca*, Newm., first larval instar, labium (× 208).

underside of the head, below and between the two maxillae; there is no separate basal piece visible. The 1st segment is about as long as wide, the 2nd a little narrower, only slightly more than half as long as wide, the 3rd very slightly narrower still, as long as wide, and with its basal 3rd just slightly constricted off from the rest by a faint suture; this suture indicates the line along which this segment divides into two at the next instar, when the palpi become definitely five-segmented. The 4th or terminal segment is somewhat acorn-shaped, nearly twice as long as broad, and longer than the basal segment; at its apex it carried a set of five small sensory organs in the form of short, stiff, cylindrical chitinous projections. Large tactile setae are situated as shown in text-fig. 4.

Thorax: *Prothorax* about as long as head, but broader, with a large shield-like pronotum, quite smooth and devoid of microtrichia, but carrying 10 primary setae on either side, as shown in text-fig. 2. A conspicuous *spiracle*, the only one present on the thorax, is to be seen rather low down at the back of the prothorax on either side, in the softer portion lying just in front of the mesothorax; it is circular, with a small central aperture, and measures about 0·03 mm. in diameter. *Meso-* and *metathorax* about equal, each shorter than the prothorax, but of about the same breadth; primary setae as shown in text-fig. 2. Each of these segments shows signs of a transverse division on the notum by a slightly impressed line at about two-fifths of the segments' length from the anterior border, similar to that shown in abdominal segments 1–7. *Legs* very strongly formed, of burrowing type, with large coxae, stout, somewhat curved, forwardly projecting femora, and short tibiotarsi carrying large digging-claws curved backwards. The forelegs are the largest and possess the strongest claws; the middle legs are considerably shorter, the hindlegs slightly smaller than the middle ones. The coxae of the forelegs are inserted fairly close together, those of the other two pairs much further apart.

Abdomen greatly curved, broadest at base, tapering gradually towards apex. First eight segments clearly marked, each with its pair of small circular spiracles, of which the first seven are only about half as large as the prothoracic, the 8th a

little larger than the others ; 9th and 10th segments smaller, not so clearly separated from one another ; apex very hairy. Primary setae as shown in text-fig. 2. The 10th segment ends somewhat conically in a small *anal papilla*, on which three weakly formed triangular flaps conceal a slight depression. Within this, in a carefully cleared slide, an exceedingly minute round hole can be seen, which is probably the opening of the silk glands, the original anus having been modified for this purpose.

Chaetotaxy : The primary setae of the head, prothorax, and last two segments of the abdomen are on different plans from one another and from the rest of the segments, and are not here discussed further. Those of the first eight abdominal segments, meso- and metathorax are arranged on a closely similar plan, which is comparable with that of the primary setae in the larvae of Lepidoptera, as set forth by Fracker (1915). This author names the setae by Greek letters. His method will be adopted here ; but in order to make the chaetotaxy simpler to understand, I shall also arrange the setae in groups to which positional names can be given, on the following plan :—

| *Position.* | *Names.* | |
|---|---|---|
| | *Anterior Seta.* | *Posterior Seta.* |
| Dorsal .. .. .. .. .. | $\alpha$ (absent) | $\beta$ |
| Latero-dorsal .. .. .. .. | $\gamma$ | $\delta$ |
| Lateral or Peristigmatic :— | | |
| Upper .. .. .. .. | $\varepsilon$ | $\rho$ |
| Lower .. .. .. .. | $\eta$ | $\kappa$ ($\mu$) |
| Latero-ventral .. .. .. .. | $\nu$ | $\pi$ |
| Ventral or Coxal :— | | |
| Upper .. .. .. | $\tau$ | $\psi$ |
| Lower .. .. .. .. | $\omega$ | $\sigma$ |

By using this table, each seta receives, besides its Greek name, a *positional name* which may be found more useful, if somewhat longer ; *e.g.* $\beta$ becomes the *posterior dorsal seta*, $\eta$ the *lower anterior lateral seta*, and so on.

Fracker, in his work, indicates twelve primary setae for a typical segment in the first instar of the Lepidopterous caterpillar. These are : alpha, beta, gamma, delta, epsilon, rho, eta, kappa, pi, nu, tau and sigma. He also indicates three others as subprimaries, which are setae arising at the first ecdysis ; they are theta, mu and omega. Of the twelve primary setae, only one, alpha, appears to be absent from *Ithone*, while another, tau, only appears on the metathorax. Of the subprimaries, theta is never present in *Ithone*, thus supporting Fracker's contention that its absence from the first instar in Hepialidae shows that it is not a true primary seta ; mu is present only on the metathorax ; and omega occurs on both metathorax and abdominal segments. It would thus appear that omega is really a primary seta for *Ithone*, and takes the place of the more dorsally situated tau, present in the Lepidoptera. This could be easily understood if both omega and tau were actually primary setae for the ancestral Panorpoid type, the upper seta being suppressed in *Ithone*, the lower in Lepidoptera. The seta which I have called psi appears to have no homologue in Lepidoptera.

Text-fig. 5 shows the chaetotaxy of the metathorax and first two abdominal segments of *Ithone* in diagrammatic form. From the mid-dorsal line to the dotted lateral line above pi, the microtrichia are exceedingly abundant, being only absent from certain areas around the primary setae which correspond with the hardened plates or *pinacula* of Mecopterous and Lepidopterous larvae, but which, in *Ithone*, are simply clear, unhardened areas. Each primary seta has a small circular area surrounding it, except in the case of eta and kappa, around which there is a larger pinaculum enclosing both, and represented by a dotted line in text-fig. 5. On the meso- and metathorax, there is also a much larger pinaculum enclosing gamma,

delta, epsilon and rho. I have used the condition of this pinaculum as a convenient diagnostic character for determining the first three instars, as may be seen from text-figs. 5–7. Below the dotted line microtrichia are very weakly developed for a space, this area always including pi ; but, lower down, they again come more into evidence.

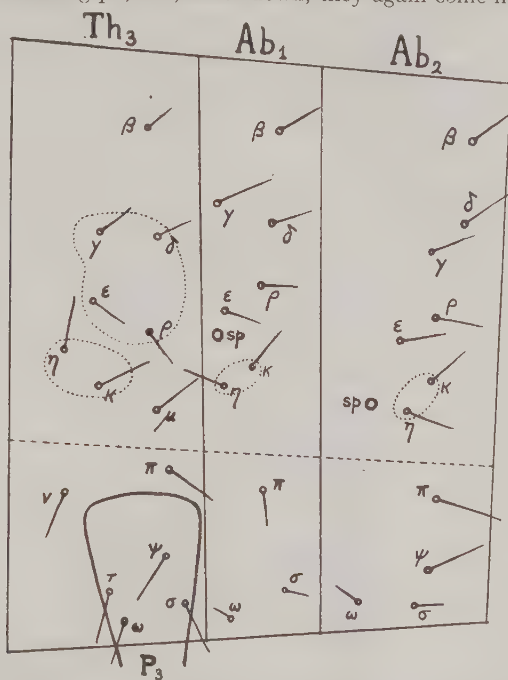



Fig. 5. *Ithone fusca*, Newm., first larval instar ; diagram of chaetotaxy of metathorax ($Th_3$) and first two abdominal segments ($Ab_1$, $Ab_2$), to show positions of primary setae, with Fracker's notation ; $P_3$, coxa of hind leg.

Secondary setae of the type which appears on the metathorax in the second instar are already present on the anal papilla at the first instar, and the end of the abdomen is conspicuously more hairy than the rest of it ; so that we are justified in considering segment 10 as already specialised in this larva.

During the first instar, the larvae grow considerably, the prothorax and back of the head swelling out with the other segments. But this instar can always be recognised by the comparatively large size of the head, the small, circular spiracles, and the presence of the primary setae only on the thorax and first eight abdominal segments.

**Second Larval Instar** (Plate iv, fig. 3 ; text-fig. 6).

The second larval instar superficially resembles the first, except for its larger size and the comparatively smaller size of the head in relation to the prothorax. The head is more swollen below the bases of the maxillae, and there is a distinct beginning of the tendency, so noticeable in the later instars, for the mouth-parts to turn upwards. The labial palps are definitely five-segmented. The three pairs of legs are more nearly equal in size than in the first instar. The spiracles are greatly enlarged, and of a broad oval shape, with the aperture in the form of a wide slit ;

the prothoracic spiracle now measures 0·1 mm., while that of the first abdominal segment measures 0·06 mm. in length, the breadths being about two-thirds of these measurements in each case. All the segments show a new development of fairly numerous secondary setae of macrotrichial type, but not so long as the primary setae. On the pro- and mesothorax these setae are nearly all very slender, less than half as long as most of the primary setae; the pronotum remains shield-like and smooth, without any microtrichia, but the mesonotum has the microtrichia very strongly developed, as have all the succeeding segments. The secondary setae on abdominal segments 2–8 are slender and comparatively short, like those of the

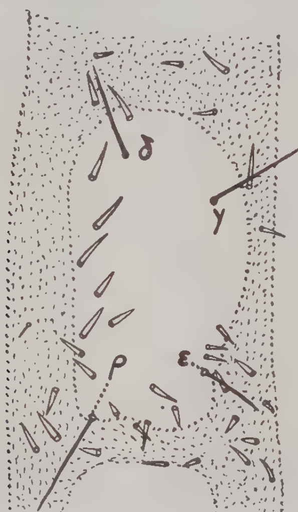



Fig. 6. *Ithone fusca*, Newm., second larval instar; large pinaculum of metathorax, showing invasion of secondary setae (× 112),

pronotum; those on the first abdominal segment are slightly thicker, and those on the metanotum are very distinctly thickened, so that they can be distinguished at a glance from the primary setae, which remain in position. The invasion of these setae upon and around the large pinaculum of the metathorax, which encloses the four primary setae gamma, delta, epsilon and rho, is shown in text-fig. 6.

**Third Larval Instar** (Plate iv, fig. 4; text-fig. 7).

The third instar is again considerably larger than the second, but owing to actual differences in the sizes of individual larvae, measurements cannot be relied upon to determine the correct instar. The head is again smaller in comparison with the prothorax than in the second instar, and the turning-up of the mouth-parts is distinctly more noticeable. Antennae and labial palpi remain five-segmented. The spiracles are now very oval in shape, the prothoracic spiracle measuring 0·16 mm., and being only half as broad as long, while the first abdominal spiracle is 0·10 mm. long, and a little more than half as broad. Transverse striation of the lips of the spiracle and of its internal opening is now apparent. The most noticeable change in this instar is the very large invasion of secondary setae on all the segments; the

condition of the large pinaculum on either side of the metathorax is shown in text-fig. 7. It is no longer possible to pick out the primary setae with certainty on the abdominal segments, as the lengths of the secondary setae are by now very nearly the same.

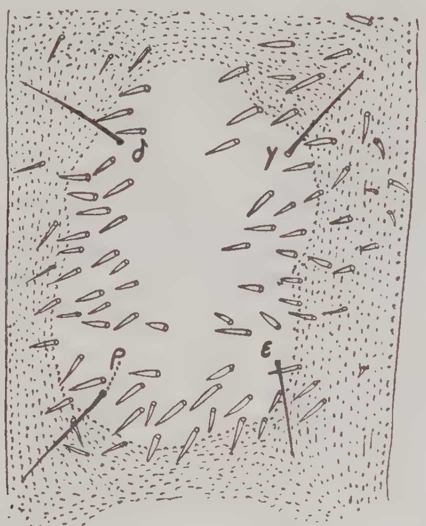



Fig. 7. *Ithone fusca*, Newm., third larval instar; large pinaculum of metathorax, showing the great increase in the number of secondary setae (× 112).

**Fourth Larval Instar** (Plate iv, fig. 5; text-fig. 8).

In this instar, the head is further reduced in size in comparison with the prothorax, and is now less than half as wide as the latter, and considerably shorter, as can be seen from text-fig. 8. The turning-up of the mouth-parts is very noticeable, as is also the development of the swollen ventral portion of the head beneath the maxillae.

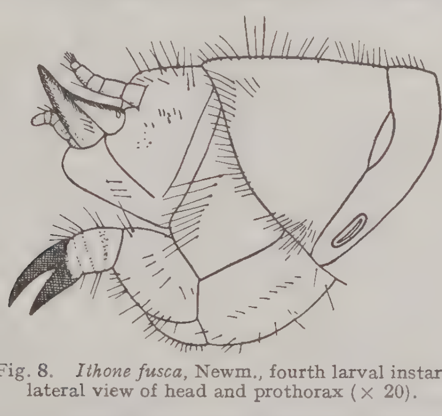


Fig. 8. *Ithone fusca*, Newm., fourth larval instar; lateral view of head and prothorax (× 20).

The upper claw of the fore tarsus is now about as long as the maxilla; in all previous instars it is considerably shorter. The primary chaetotaxy has disappeared, or can no longer be recognised; the setae on the head and prothorax are shown as in

text-fig. 8, while those on the remaining segments are very minute and abundant. The most striking change is in the size and shape of the spiracles. The prothoracic spiracle is now twice as long as in the previous instar, measuring 0·32 mm. in length; its breadth is only one-fourth of its length, and the internal aperture has become a very narrow and elongated slit. The first abdominal spiracle is 0·19 mm. long, somewhat broader in proportion to its length than the prothoracic. Transverse striation or ribbing of the lips is clearly noticeable. Antennae and labial palpi remain five-segmented, but the terminal segment of the latter turns downwards. There is a slight indication of the beginning of a division of the tibio-tarsus into three segments.

**Fifth (last) Larval Instar** (Plate iv, figs. 6, 7; text-fig. 9).

The last instar closely resembles the preceding, except for its greater size. The head is still further decreased in breadth and length in comparison with the huge prothorax; its breadth is now barely one-third of that of the latter. The antennae are usually five-segmented, but I have occasionally noted six segments in this instar; the two end segments tend to turn upwards. The labial palpi are still five-segmented,

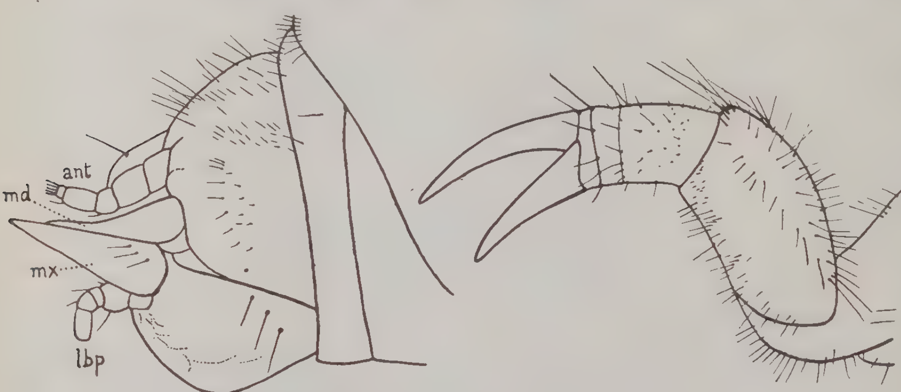



Fig. 9. *Ithone fusca*, Newm., fifth larval instar; lateral view of head and foreleg, with mandible, maxilla and tarsal claws left unshaded (× 20).

with the two terminal segments turning sharply downwards. The ventral portion of the head is now greatly swollen and corrugated for the attachment of the maxillary muscles. The upper claw of the fore tarsus is definitely longer than the maxilla, and the tibio-tarsus shows distinct signs of division into three segments, of which the basal one is twice as long as the other two together. The whole series of spiracles now appears as a row of transverse slits, very much longer than broad. The prothoracic spiracle is 1·13 mm. long, the first abdominal 0·60 mm.; the internal apertures are very narrow slits extending nearly the whole length of the spiracle. The edges of the internal apertures can be seen to be curved over and definitely marked with transverse ribs, as are also the lips of the spiracle itself. The 9th abdominal segment carries a ring of conspicuous dark hairs, not noticeable in the previous instar.

**Formation of the Cocoon** (Plate iv, fig. 9).

When the larva is full-grown, it ceases to feed for some considerable time, and makes its way down to a somewhat lower level where the soil is slightly moister than that in which it lives as a larva. Having chosen a suitable place, it hollows out an elongated oval cell in the moist soil, by continually coiling itself round and

round, bringing its head forward close to the ventral side of its abdomen, and then turning right over and repeating the same performance. When this cell is securely formed, by continuous pressure on the soil, the larva lies upon its back, and proceeds to weave the cocoon from the anal opening in the same manner as other Planipennia. The complete process has not been observed, but I was fortunate enough to see one larva with its cocoon partly formed, in which the separate fine layers of silk were clearly visible. The cocoon, when completed, is elongate oval in shape, a little less than thrice as long as wide, with almost parallel sides and well rounded ends. It is of a dead whitish colour and a papery consistency, the texture reminding one more of that of some Hymenopterous cocoons than of those of other Planipennia. The insect spends on an average about six weeks in the cocoon; during the first half of this period it remains a larva, and then changes into a pupa.

The earliest cocoon found by me was on 12th September, but most of the larvae spin up during the succeeding fortnight. The earliest emergence of the imago noticed during the same year was on 30th October. The period spent in the cocoon is thus seen to be about six weeks on the average, or a little over.

**The Pupa** (Plate iv, figs. 10, 11; text-figs. 10, 11).

The pupa is a soft-bodied *pupa libera* of elongate form, having the rather small head turned down ventrally in front of the somewhat larger prothorax, which lies about at right angles to the main axis of the body. The rest of the thorax is curved round dorsally to join the long, straight, stout abdomen, which is only slightly curved

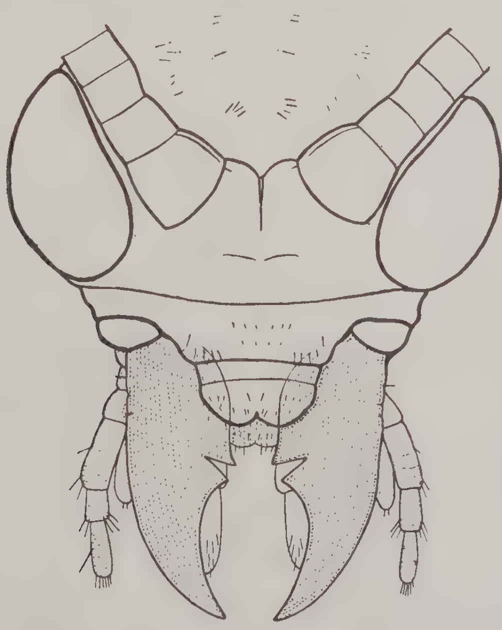


Fig. 10. *Ithone fusca*, Newm., pupa; front of head, showing compound eyes, bases of antennae and mouth-parts (× 20).

ventrad at its anal end. The wings are folded down sideways against the thorax, the tip of the forewing reaching only to about the middle of the 3rd abdominal segment. The antennae are curved at first upwards and backwards so as to pass over the bent knees of the three pairs of legs, and then curve round so as to lie close

alongside the front border of the wings. The legs are hunched up so that the knees are drawn back to the level of the eyes, the tibiae and tarsi lying ventrally along the first four abdominal segments. The whole pupa is at first of a soft creamy white colour, except for a slight darkening of the anal end, and the mandibles, which are a rich brown. This is well shown in Plate iv, fig. 10. The head, legs and abdomen are freely movable, and the mandibles are also capable of movement in one plane only. The pupa is able to lift its head up to a considerable extent; this attitude is shown in Plate iv, fig. 11; but it usually rests with its head downwards as in fig. 10.

Text-fig. 10 shows the structure of the front part of the head. There are no *ocelli*, but the *compound eyes* are well developed, and placed far apart, with the large bases of the *antennae* between them. The latter consists of about 54 segments, of which the basal one is larger than the others; the moniliform appearance of the antennae is well seen in Plate iv, fig. 10. The *frons* is clearly divided from the *epicranium* by an impressed transverse line; the middle portion of the *frons* projects forwards slightly as shown in text-fig. 10. Attached to this middle portion is the clypeo-labrum, which is now clearly divided into a smaller upper *clypeus* and a larger lower *labrum*, the free margin of which is well rounded, and notched in the middle. The huge *mandibles* (shaded in text-fig. 10) project downwards in the form of two broad-bladed, strongly curved and sharply pointed knife-like appendages, having the lower half of the inner margin convex, the outer half strongly concave, and the angle between them deeply notched so as to form two strong teeth placed close together. Their length is 1·8 mm., more than thrice as long as the imaginal mandibles which form within their bases. Their function is to tear open the cocoon for the exit of the pupa; it is also possible that they may assist the pupa in its progression through the soil, the legs being almost useless for this purpose.

The *maxillae* are fully formed, as shown in text-fig. 11*a*, with broad, short cardo and stipes, lacinia, galea and palp complete. The *lacinia* (*lc*) is a broad, flat process, with its oblique distal margin fringed with numerous short hairs. The *galea* (*g*) is a narrower, somewhat oval process, with three small hairs on its rounded apex. The *palp* (*p*) is fairly long, five-segmented, the basal segment being very short, the 2nd twice as long, the 3rd as long as the first two taken together, the 4th about as long as the 2nd, and the 5th as long as the 3rd, but narrower, with bluntly rounded apex carrying a set of rather short bristles; the 4th segment carries a set of longer hairs apically.

The *labium*, with attached *hypopharynx*, is shown in text-fig. 11*b*. The *labium* itself consists only of a broad, short base carrying two large, three-segmented *palpi*, in which the basal segment is the shortest, the other two being about equal. Setae are scattered about on the 2nd and 3rd segments, and the latter carries a set of stiff apical bristles. The *hypopharynx* (*hp*) consists, as in other Planipennia, of a short, bilobed tongue-like process projecting above the basal piece of the labium; each free lobe carries a few short setae.

A day or two before the imago emerges, the pupa turns a dark smoky colour, while the wing-sheaths gradually darken until they become quite black and shiny. During the later part of pupal life, the formation of the parts of the imago within those of the pupa can be watched with ease. From a pupa still more than a week from emergence, and not yet darkened in colour, I was able to draw out undamaged the whole of the imaginal antennae, mouth-parts and legs. As a full account of the imago has already been given in my previous paper, reference should be made to it for a comparison of the pupal parts with those of the imago itself. In general, the pupal parts are much paler, somewhat larger, and much more stoutly built than those of the imago, but their general shape is the same; the only exception is that of the mandibles, already noted. Some details of interest were noted in the formation of the legs, as shown in text-fig. 11 *c*, *d*. The tibial spurs are large and fleshy in the pupa, the imaginal spurs being much longer and narrower, as shown

in *d*. The pupal tarsus consists of six segments, the last of which is a swollen bulb, shallowly divided into two rounded apical lobes. From this segment there develop the two claws (*cl*) and the empodium (*em*), as shown in *c*. The lengths of the tarsal segments of the imago are much greater than those of the pupa, especially the 5th, so that the boundaries of the separate segments do not correspond. The brushes of strong hairs on the segments of the imago are pressed against the sides of the pupal segments.

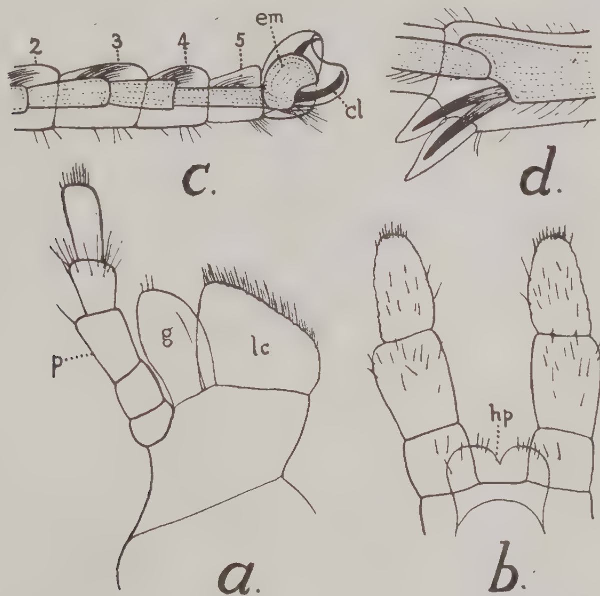



Fig. 11. *Ithone fusca*, Newm., pupa; *a*, maxilla (× 30), with galea (*g*), lacinia (*lc*), and palp (*p*); *b*, labium and hypopharynx (*hp*) (× 30); *c*, portion of hind tarsus of late pupa, showing the arrangement of the segments of the imaginal tarsus within, and the formation of the claws (*cl*) and empodium (*em*) from the terminal pupal segment; *d*, end of hind tibia of late pupa, showing formation of tibial spurs of imago (× 20).

The cocoon is cut open at about one-fifth of its length from the head end. This cut is quite irregular, and appears to be made by the mandibles first pushing their sharp points through the envelope, and then catching the torn edge between the two pairs of teeth and ripping it sideways until the top of the cocoon is entirely torn off. (The tear visible in the cocoon in Plate iv, fig. 9, was not made by the insect.) As the imagines emerge from the ground about sundown, it is to be supposed that the pupa, after getting free from the cocoon, comes to rest at some point in the soil where the warmth of the sun is noticeable, and waits until a slight cooling takes place before the imago discloses itself. Most of the cocoons being from a foot to more than two feet down in the soil, it would appear impossible for the pupa itself to be able to sense the position of the sun at such a depth.

This brings the account of this remarkable life-history back to the point at which it was begun. It now remains for me to discuss the feeding habits of the larva, and to point out its probable value in the field of economic entomology as an enemy of Grass-grubs.

**Feeding habits of the Larva.**

Mr. Gallard and I have both satisfied ourselves that the natural food of this larva is the Scarabaeid grubs which it superficially resembles. A dissection of the larva shows that it has no true mouth, and that only liquid food can be taken, in the same manner as in the case of other Planipennian larvae. No faeces are formed, and the structure of the hind gut and anus shows that this part has become specialised for the production of silk only. The question, then, was as to what was its natural food. A collection of all the forms of animal life inhabiting the sandy soil in which *Ithone* lives yielded only the following results: (*a*) cocoons of Thynnid wasps; (*b*) larvae and pupae of Brachycerous Diptera, chiefly Asilidae; (*c*) larvae and pupae of Coleoptera, chiefly Scarabaeidae; (*d*) occasional burrowing Lepidopterous larvae, chiefly those of Hepialidae.

That the larvae of *Ithone* do not normally feed upon (*a*) or (*b*) is obvious, these two groups being themselves predacious, and most probably attacking *Ithone* itself as well as other larvae. In fact, a Thynnid cocoon has recently been obtained by me from a live *Ithone* larva which was put away in a jar of soil some weeks previously. Of (*c*) and (*d*) we can say at once that the latter are far too uncommon to supply the amount of food necessary for the large number of *Ithone* larvae present in the soil. The only food that is present in the requisite amount is the Coleopterous larvae, of which more than ninety per cent. consist of Scarabaeid grubs, more or less closely resembling the larva of *Ithone*. One of these, shown in Plate iv, fig. 8, is so like *Ithone* when first dug up that we came to call it the "false *Ithone*"; we have not succeeded in rearing it to determine to what species it belongs.

On several occasions I placed a number of Scarabaeid larvae in soil in a large jar and then turned out a few *Ithone* larvae on top of the soil. The *Ithone* larvae at once burrowed rapidly down, and kept working away round and round the jar. Approaching a Scarab larva, they appear always to burrow down below it, and then work up towards it from below. I have not actually succeeded in seeing an *Ithone* larva attack any of its victims, but have no doubt that it is done by an upward stroke, judging by the formation of its mouth-parts. On examining one jar of larva the following morning, I found all the Scarab larvae killed, one having been sucked almost dry, another partly sucked, and the rest having one or more clearly marked wounds which had caused their death. One *Ithone* larva was also wounded, and died later; this may have been from an attack by another *Ithone* larva, or possibly the wound was caused by the jaws of the Scarab larva which it was attacking. Mr. Gallard had also observed, on more than one occasion, the death and partial sucking-out of Scarab larvae to which *Ithone* larvae have been given access.

We can only conclude that the principal diet of the larva of *Ithone* consists of Coleopterous larvae, chiefly those of Scarabaeidae; though this does not preclude the probability that they also attack Hepialid and other larvae when hungry.

**The Economic Value of the Ithonidae.**

The family Ithonidae is widely spread throughout Australia, being found from Queensland down into New South Wales and Victoria, and across the central desert into Western Australia. One species, *Heterithone pallida*, Till., is common in many localities in Tasmania. The larvae must, therefore, be capable of standing great extremes of temperature in the soil. The insects are most abundant along the sandy foreshores and wherever the soil is of a light, loose texture suitable for easy burrowing. These are also the conditions which best suit the various species of Grass-grub. But, just as Scarabaeid grubs are also to be found in heavier soil, so there is evidence that *Ithone* also exists there, though not so abundantly. One species has been taken on Mount Tambourine, where the soil is of volcanic origin; the larva of another has been found by Mr. Gallard in a heavy loam at Epping. Isolated records of the occurrence of the imago come from many parts of the interior of Australia also, so that the insect is by no means confined to the coastal strip.

Grass-grubs are a serious pest in many parts of the world, and any addition to the list of their enemies should be very welcome. In New Zealand, much damage is caused at times by these pests, which do not seem to have any enemies there except a few introduced birds. In attempting to control this pest, there appears to me to be three lines of attack, viz., Ithonidae, Scoliidae and Thynnidae. It would be unwise to rely upon one only, when all three are available. One must, however, take into consideration the popular objection to the introduction of any new large wasp into a country devoid of them. I have therefore started my attempt to reduce this pest by introducing *Ithone* into New Zealand. Last October I went across to Sydney, and, with the help of Mr. Gallard, secured, as already related, some 7,000 fertile eggs of *Ithone fusca*, 5,000 of which were sent to New Zealand. These have been distributed in lots of 500 to the following centres: Wellington, Auckland, Christchurch,Wanganui, Hokitika, Blenheim; and, within Nelson province, Murchison Mapua, Richmond, Tahunanui, Dun Mountain (250). Besides these, 750 eggs have been sown in specially prepared grass plots liberally supplied with *Odontria* grubs in the grounds of the Cawthron Institute, and covered over with bird-proof netting. These will be opened up and examined during the coming winter, to see whether the *Ithone* larvae have succeeded in establishing themselves under the new conditions of food, climate and soil. Plate v shows these plots in their present condition (17th March 1922), with the Insectarium in the background.

*Cawthron Institute, Nelson, N.Z.*
*17th March, 1922.*

*Literature Quoted.*

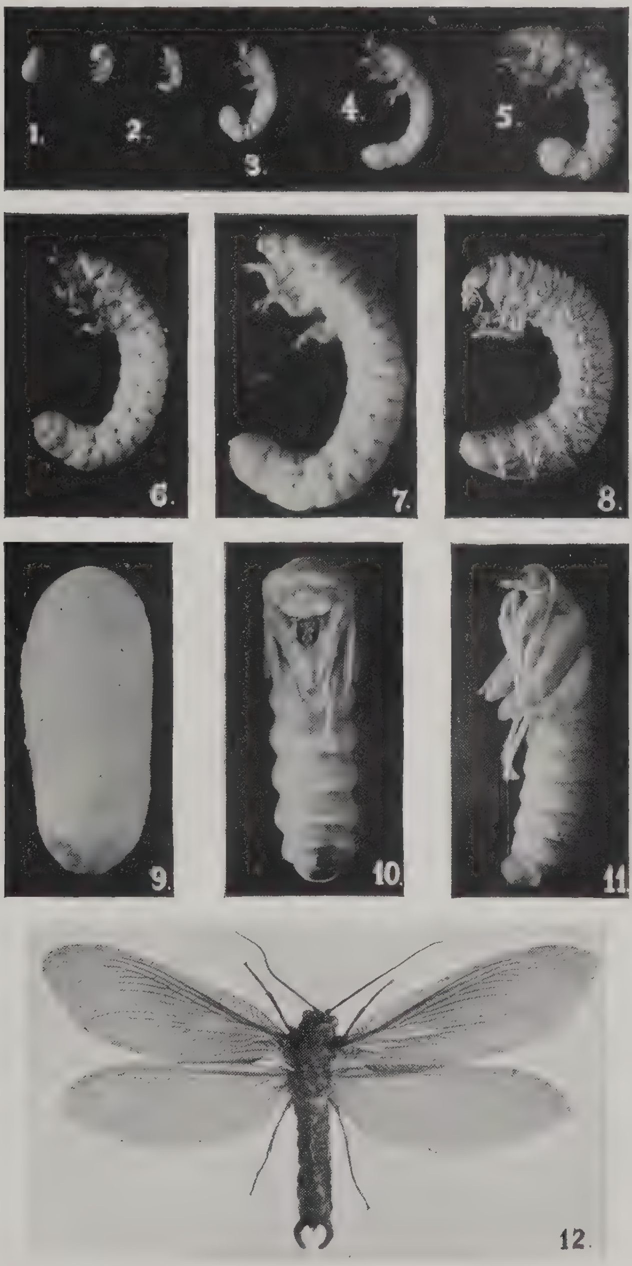
Fracker, S. B. (1915). The Classification of Lepidopterous Larvae.—Illinois Biol. Monographs, ii, no. 1, July 1915.

Tillyard, R. J. (1919). Studies in Australian Neuroptera, no 8. Revision of the Family Ithonidae, etc.—Proc. Linn. Soc. N.S.W., 1919, xliv, pt. 2, pp. 414-437.

## EXPLANATION OF PLATE IV.

Life-history of *Ithone fusca,* Newman.

Fig. 1. Egg (× 3).
,, 2. Two newly hatched larvae (× 3).
,, 3. Larva, second instar, approaching ecdysis (× 3).
,, 4. Larva, third instar (× 3).
,, 5. Larva, fourth instar (× 3).
,, 6, 7. Two larvae of fifth or last instar (× 1·9).
,, 8. Scarabaeid larva found with *Ithone* larvae, and superficially resembling it; last instar (× 1·9).
,, 9. Cocoon (× 1·9).
,, 10. Pupa, front view (× 1·9).
,, 11. Pupa, side view (× 1·9).
,, 12. Male imago (× 2·2).




Life-history of *Ithone fusca*, Newman.

A view of the prepared grass plots containing grass-grubs and sown with *Ilhone* eggs, in the grounds of the Cawthron Institute. Insectarium in the background.

# RICE GRASSHOPPERS OF THE GENUS *HIEROGLYPHUS* AND THEIR NEAREST ALLIES.

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Species of the genus *Hieroglyphus* are well known in India as serious pests of rice, sugar-cane, *Sorghum*, and some other crops, but in nearly all economic entomological publications one species only, *H. banian*, F. (= *furcifer*, Serv.) is regarded as being noxious. It is obvious, however, from some of the earlier descriptions and figures that there is more than one injurious species, but the exact status of each one of them could not be established even in more recent economic publications owing to the very unsatisfactory state of the systematics of this group, which made correct identification of species uncertain even for a specialist and quite impossible for an economic entomologist. It is true that comparatively recently I. Bolivar (1912) and J. Carl (1916) published more or less comprehensive papers on the genus, but these papers are not revisions, as the authors did not include all the known species and hardly touched questions of synonymy; moreover, Carl's paper, though published four years after that of Bolivar, was written without any reference to the latter, which resulted in the same species being described twice under different names, thus increasing the confusion. Further, both these authors based their papers on insufficiently extensive material, so that they were unable to appreciate the range of variation in the species.

The purpose of this paper is, therefore, to give a critical study of all the known species of the genus *Hieroglyphus* and of two more genera closely allied to it and liable to be confused with it. To make the paper of more practical use for field entomologists, all the most important characters used to separate the species are figured, so that identification of specimens by the keys should not be difficult.

The bulk of the material on which the paper is based has been received from the collection of the Agricultural Research Institute, Pusa, owing to the courtesy of Mr. T. Bainbrigge Fletcher, to whom my thanks are due. I am much obliged also to Mr. Y. Ramachandra Rao, who sent me material from the Coimbatore Agricultural College; to Prof. Dr. Richard Ebner, and to the authorities of the Wiener Staats-museum for lending me material from that Museum, including co-types of one of Brunner v. Wattenwyl's species; to Dr. Candido Bolivar for sending me for study the type of one of I. Bolivar's species; and to Dr. W. Lundbeck, of the Zoological Museum in Copenhagen, who sent me a co-type of *H. banian*, Fabr.

The three genera belonging to the group under revision may be separated from all other Acridians by the following combination of characters:—

Prosternum armed with a straight conical spine. Mesosternal lobes with the hind inner angles rounded. Pronotum cylindrical, without lateral carinae, without or with but a feeble and incomplete middle carina, with 3–4 transverse sulci, which are mostly very deep (in *Parahieroglyphus* feeble, but distinct). Hind femora with the upper middle keel not prolonged into a tooth at the apex. Hind tibiae with the upper margins (*i.e.*, between the spines) rounded, not expanded; with a rigid outer apical spine close to the two movable outer apical spurs. Lower valves of the ovipositor with 1–2 large teeth, but not serrate. General coloration green, yellowish, or brownish, with or without black marks on pronotum, sternum and hind knees, tibiae and tarsi.

*Key to the Genera.*

1 (2). Upper surface of the pronotum only feebly convex (fig. 1 D); transverse sulci feeble, but distinct, cutting all the keels. Cerci of the male very large, divided into three vertical lobes; male subgenital plate small, obtusely conical, not longer than its basal width. Subgenital plate of the female with its apex divided into three lobes .. .. .. .. *Parahieroglyphus*, Carl.

2 (1). Upper surface of the pronotum strongly convex; transverse sulci deep (figs. 1 A, 1 C).

3 (4). Median keel of the pronotum low, but quite distinct throughout, interrupted by the transverse sulci, but nowhere obliterated (fig. 1 C). Cerci of the male with their basal part thick and cylindrical, strongly recurved, projecting vertically above the supra-anal plate (fig. 2, C, D). Male supra-anal plate broader than long (fig. 2, C). Female subgenital plate with the apex trilobate (fig. 2 B) .. *Hieroglyphodes*, gen. nov.

4 (3). Median keel of the pronotum altogether or partly obliterated, or else very feeble (fig. 1 A). Male cerci more or less cylindrical throughout, directed backwards or obliquely upwards, but never recurved, with the apex simple, truncate, bifurcate or appendiculate. Male supra-anal plate longer than it is broad (fig. 1 E, F). Female subgenital plate with the apex not divided into three lobes (fig. 2 A) .. *Hieroglyphus*, Krauss.

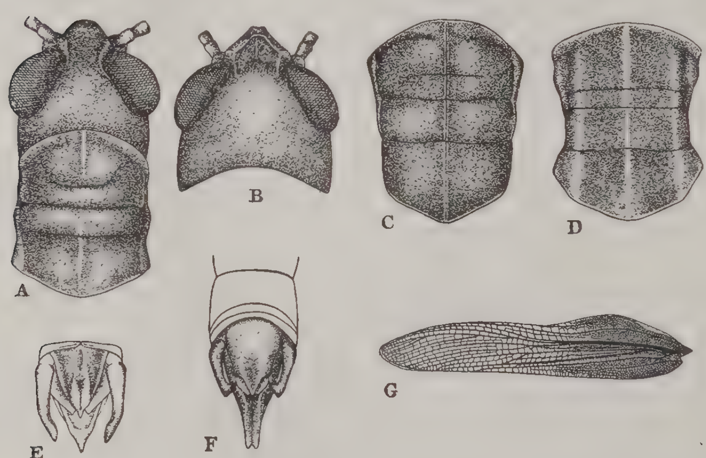


Fig. 1. A, *Hieroglyphus banian*, F.; B, *H. africanus*, sp. n.; C, *Hieroglyphodes assamensis*, g. & sp. n.; D, *Parahieroglyphus bilineatus*, Bol.; E, *H. annulicornis*, Shir., male genitalia; F, *H. daganensis*, Kr., male genitalia from above; G, *H. annulicornis*, Shir., elytıon.—All figures × 4.

Genus **Parahieroglyphus**, Carl.

1912. *Hierocer*y*x*, I. Bolivar, Trab. Mus. Madrid, no. 6, pp. 50, 59 (*nomen praeoccupatum.*)

1916. *Parahieroglyphus*, Carl, Rev. Suisse Zool., xxiv, no. 6, p. 482.

Genotype: *Hieroceryx bilineatus*, Bol.

Though Bolivar's name for the genus is four years older than that of Carl, it must give way to the latter, as the name *Hieroceryx* has been used already in 1896 by Tosquinet for a genus of Hymenoptera (Mem. Soc. Entom. Belg., V, p. 267).

The genus is somewhat aberrant from the two others owing to its pronotum being distinctly compressed laterally and flattened above, which makes its transverse section not circular, as in the two other genera, but almost quadrangular, though there are no lateral keels and the upper surface of the pronotum forms widely rounded angles with the lateral lobes.

Only two species are known in this genus, but one of them, having been described from a single female, is not easily recognisable, as the best specific characters are to be found in the male cerci ; as I know this species only from a hitherto undescribed male, I cannot be quite sure of its specific determination, but I refrain from describing this male as new, until its identity has been definitely cleared up by a study of both sexes. There is no doubt that additional undescribed species will be discovered, but I should like to warn all future students against describing species from specimens of one sex only, and especially from females.

*Key to the Species.*

1 (2). Front in profile straight. Vertical diameter of an eye twice as long as the horizontal one. Male cerci with the first (anterior) lobe as high as the middle one. Lateral lobes of the female subgenital plate about half as broad as the middle one and reaching beyond its middle.—N. and N.E. India .. .. .. .. .. .. 1. *P. bilineatus*, I. Bol.

2 (1). Front in profile convex. Vertical diameter of an eye less than twice as long as the horizontal one. (? Male cerci with the anterior lobe much shorter than the middle one).—S. India .. 2. *P. colemani*, I. Bol.

1. **Parahieroglyphus bilineatus,** I. Bol. (fig. 1, D).

1912. *Hieroceryx bilineatus*, I. Bolivar, Trab. Mus. Madrid, no. 6, pp. 60, 61.

1914. *Hieroglyphus bilineatus*, Kirby, Fauna Brit. India, Acrid, p. 202.

1916. *Parahieroglyphus bilineatus*, Carl, Revue Suisse Zool., xxiv, no. 6, p. 483, pl. ii, figs. 2–5.

The species was given by Saussure the manuscript name *Hieroglyphus bilineatus*, and sent under it to different museums, with the result that it has been three times redescribed since by as many authors, but always under the same name. The British Museum has also a male and a female of it from Saussure, labelled in his own writing.

Kirby's note, on H. Maxwell-Lefroy's authority (l.c. p. 203), that this species is only a micropterous form of *Hieroglyphus banian*, is, of course, a serious mistake ; his description of the male cerci as " obtuse " is also very far from being correct.

As I have before me only four specimens of this insect, I am not in a position to estimate the extent of its variability. There is no doubt, however, that some of its characters must be subject to individual variation ; this is to be expected with regard to general dimensions and coloration, while the venation of elytra, which Bolivar uses as a specific character differentiating *P. bilineatus* from *P. colemani*, is also not constant, not being the same even on the right and left elytra of one specimen.

*Specimens studied.*—Indes orient., 1 ♂, 1 ♀ (from Saussure) ; India, 1 ♂ ; Dehra Dun, Ollenbach, x.06, 1 ♀ (Pusa Coll.).

*Geographical distribution.*—J. Carl, who described this species from the original series of Saussure, gives the locality as " Indes orientales, Himalaya," and it seems that the species belongs to Northern India, though the lack of records from the Indian peninsula proper may be due simply to insufficient exploration.

2. **Parahieroglyphus colemani,** I. Bol.

1912. *Hieroceryx colemani*, I. Bolivar, Trab. Mus. Madrid, no. 6, p. 61.

1914. *Hieroceryx colemani*, Coleman, Journ. Bombay N.H. Soc., xxiii, p. 175, plate, fig. 3.

As I have already mentioned, the species has been described from a single female, and I have before me a single male, which makes its specific identification rather uncertain. There is, however, no doubt whatever that my male is specifically distinct from *P. bilineatus*, since the difference in the cerci is very conspicuous ; other differences from *P. bilineatus* indicated in the key agree with the characters used by Bolivar to separate the latter from *P. colemani* and with the figure given by Coleman, so that I refer my specimens to that species, although with some doubt.

*Specimen studied*.—Surat, Bombay, x. 1903, 1 ♂ (received from Pusa).

*Geographical distribution*.—Bolivar described the species from Anavatti, in the Shimoga district of Mysore ; my male is from Surat, so that the species may be restricted to the Indian peninsula.

*Economic importance*.—According to Coleman (*l.c.* p. 174) this insect has been found in small numbers associated with *Hieroglyphus banian* in rice-fields at Anavatti.

3. **Parahieroglyphus** sp.

There are in the Pusa material two females from Pardi, Bombay, 23.ix.1904, which are clearly not *P. bilineatus*, but which I hesitate to identify with *P. colemani* either. They are distinctly larger in size than is the female of the latter species, according to Bolivar's description, while in the shape of the head and the eyes, they agree with it, so far as can be judged by description. From *P. bilineatus* they differ in the shape of the subgenital plate, which has the lateral lobes very narrow and not longer than half of the middle lobe. I abstain from describing the species as new until the male is known.

## Genus **Hieroglyphodes,** nov.

More like *Hieroglyphus* than *Parahieroglyphus*, but more closely related to the latter. Head large and thick, strongly reclinate. Frontal ridge sulcate throughout, with the margins feebly divergent downwards. Fastigium of the vertex distinctly sloping, forming an acute rounded angle with the frontal ridge ; with a bow-shaped transverse sulcus, and a feeble longitudinal carina between the eyes. Pronotum cylindrical, slightly narrowed posteriorly ; the transverse sulci well developed, three of them cutting the median keel, which is low but well developed throughout ; the metazona distinctly longer than half the prozona ; hind margin obtusely angulate. Posternal spine acutely conical. Mesosternal lobes subtransverse ; their interspace X-shaped, constricted before the middle and strongly widened posteriorly, but the lobes not touching each other even in the male. Metasternal lobes touching each other in the male and narrowly separated in the female. Elytra abbreviated, of the same shape as in *Parahieroglyphus*. Abdomen in the male with the apex recurved ; supra-anal plate rotundato-trapezoidal, with several complicatedly curved obtuse ridges ; cerci inflated basally, strongly recurved, with the incrassate apex lying on the anal plate ; subgenital plate short, strongly recurved. Subgenital plate of the female trilobate apically.

Genotype : *Hieroglyphodes assamensis*, sp. n.

1. **Hieroglyphodes assamensis,** sp. n. (figs. 1 C, 2 B, C, D).

♂. Head thicker than pronotum and distinctly longer than prozona of the latter. Frontal ridge in profile slightly convex. The foremost part of the fastigium (*i.e.*, that in front of the transverse impression) about half as broad again as long. Eyes

large, prominent ; their longest diameter about twice as long as the shortest one ; the latter is almost twice as long as the subocular distance ; the distance between the eyes somewhat broader than the frontal ridge at the clypeus. Pronotum coarsely punctured throughout, more densely in the metazona ; lateral lobes trapezoidal, with the fore margin very oblique, straight, fore angle very obtuse, lower margin obtusely angulate behind its middle, hind angle about 90°, hind margin vertical in its lowest portion and oblique in the rest. Elytra extending a little beyond the second tergite, lancet-shaped, with the apex curved downwards ; radial veins straight ; reticulation fairly dense, sub-obliterate. Wings rudimentary.

General coloration dirty olive-brown (probably more or less greenish in life). Antennae blackish below, and brown with the apex blackened above. Cheeks with a black streak starting from the hind lower margin of the eye and running obliquely towards the hind angle of the cheek, but disappearing half-way. Pronotum with the first sulcus black on the lateral lobes only ; the second sulcus is black on the sides of the disc, with the middle portion not coloured ; the third sulcus is black throughout, except in the middle of the disc, and its lower end is connected by a black line with the lower end of the first sulcus ; the last sulcus is black throughout, except the lower ends of lateral portions. Mesopleurae with black oblique streaks. Abdominal tergites with their hind margins narrowly darkened. Front and middle legs with outer spots at the apices of the femora, and also bases and apices of tibiae, black. (Hind legs in the type broken.) Elytra with short black streaks at the base of radial veins.

♀ (paratype). Twice as large as the male. Fastigium of the vertex more than twice as broad as long. Distance between the eyes almost half as broad again as the frontal ridge at clypeus. Hind femur with a round spot at the base of the knee, both inwardly and outwardly, and a narrow margin on the knee above, black. Hind tibia with the base, apex and a line along the lower side, black. Hind tarsus without black parts.

| | ♂ (type). | ♀ (paratype). |
|---|---|---|
| Length of body .. .. .. .. | 27 mm. | 41 mm. |
| ,, ,, head .. .. .. .. | 4·5 | 5·5 |
| ,, ,, pronotum .. .. .. | 6 | 8 |
| ,, ,, elytra .. .. .. .. | 8 | 10·5 |
| ,, ,, hind femora .. .. .. | — | 19 |

Described from one male and one female from Cachar, Assam (British Museum).

### Genus **Hieroglyphus,** Krauss.

1877. *Hieroglyphus*, Krauss, Abhandl. Akad. Wiss. Wien, Mat.-Nat. Classe, lxxvi(1), p. 41.

1878. *Hieroglyphus*, Stål, Bih. Svensk. Akad. Handl., v (4), pp. 48, 93.

1912. *Hieroglyphus*, I. Bolivar, Trab. Mus. Madrid, no. 6, p. 50.

1914. *Hieroglyphus*, Kirby, Fauna Brit. Ind., Acrid., pp. 192, 201.

1918. *Hieroglyphus*, I. Bolivar, Trab. Mus. Madrid, no. 34, p. 11.

Genotype : *Hieroglyphus daganensis*, Krauss.

The genus was established by Krauss to include a species from Senegal, *H. daganensis*, as well as the well known *H. banian*, F. (= *furcifer*, Serv.). One year later (1878) Stål described a third species from China, *H. tarsalis*, which is, however, conspecific with one previously described, *Oxya concolor*, Walker, as also is Brunner von Wattenwyl's *H. citrinolimibatus*, described in 1893. T. Shiraki in 1910 published a description of a species from Formosa, under the name of *Oxya annulicornis*, and this has been since twice redescribed by Bolivar (*H. formosanus*, 1912) and Carl (*H. tonkinensis*, 1916). Two more species have been added by Bolivar in his

revision of the genus, *H. tonkinensis* (*nec* Carl !) and *H. nigrorepletus*, the latter having been also twice redescribed by Kirby (1914) under *H. bettoni* and by Carl (1916) under *H. vastator*. One more Indian species, *H. oryzivorus*, has been published by Carl, and one new one from Abyssinia is described in this paper, which brings the total number of species of the genus *Hieroglyphus* up to eight, all of which are known to me, mostly by typical specimens. As, however, the majority of known species is represented in collections by very poor series of specimens, I believe that the number of species which remain still undiscovered may be not inconsiderable, and extensive collecting ought to give good results.

The geographical distribution of the genus is very peculiar and worth a few remarks. The majority of the known species occur in the plains of India, but the entire area occupied by the genus extends farther eastwards, through Burma and Assam, to Southern China and Formosa, while, on the other hand, there are already two species known from subtropical Africa. The presence of these species in Africa is the more puzzling in that although they are both very closely related to two Oriental species (indeed, so closely that they may be regarded as but geographical races of these species), there is no evidence of the Oriental and African areas inhabited by the genus being in direct connection. This latter seems to me even hardly possible at all, since, so far as the biology of representatives of this genus is known, they inhabit damp localities, with rich vegetation of grasses, reeds, etc. (not trees or shrubs), such as marshy grassland, rice and cane fields ; conditions of this kind are very common both in India and in the subtropical belt of Africa extending from Senegal and Northern Nigeria right across the continent to the Eastern Sudan, but not in the south-western part of Asia, separating those two areas, which bears more or less desert conditions throughout.

The best characters for separating species of *Hieroglyphus* are to be found in the shape of the male external genitalia, and particularly that of cerci ; accordingly it is sometimes not easy to identify a species from the female sex only, although in some cases the female genitalia also present good specific characters. The relative length of the elytra is not a specific character at all, since at least three species occur regularly in two different forms, macropterous and brachypterous, respectively ; it is very interesting to note that there are no transitional forms between the two extremes known, and an experimental study of the causes of brachypterism should be worth the trouble.

The structure of the sternum is of considerable systematic importance, but it is not altogether constant in every species. Especially noteworthy is the variability of the sternum in the most common species, *H. banian*, in which the variations in the sternum are accompanied by variations in the coloration, general habitus, size, and the shape of the head, so that two forms of the species may be distinguished ; but the real significance of these forms, as well as the causes of their appearance, are by no means clear (see below, under *H. banian*). In the other species the material available is insufficient to permit conclusions to be drawn regarding the limits of variation.

### *Key to the Species.*

1 (6). Cerci of the male simple (fig. 1 E). Subgenital plate of the female with two longitudinal denticulate or granulate carinae (fig. 2 A). Pronotum distinctly rugosely punctured.

2 (5). Male cerci scarcely longer than the anal plate and not reaching the apex of the subgenital plate, which is as long as its basal width, obtusely conical. Elytra without a false vein in the discoidal area. Pronotum more coarsely punctured. Lateral margins of the fastigium of vertex broad, punctured, with more or less distinct foveolae (fig. 1 B).

3 (4). Frontal ridge with the sulcus disappearing about half-way between the base of antennae and the top, so that the apex of the ridge is flat, punctured. The transverse sulci of the pronotum, particularly the hind one, broader. Hind tarsi above with not more than the basal half black or brown. Subgenital plate of the female with the carinae not very distinct, granulate.—Sudan, Kamerun .. 1. *africanus*, sp. n.

4 (3). Frontal ridge sulcate throughout, up to the very top. The transverse sulci of the pronotum narrower. Hind tarsi black above except not more than the apical third. Subgenital plate of the female with distinct denticulate carinae (fig. 2 A).—Burma, Sylhet, Surat .. .. .. 2. *concolor* (Walk.).

5 (2). Male cerci distinctly longer than the supra-anal plate and reaching the apex of the subgenital plate (fig. 1 E), which is longer than its basal width, with the apex attenuate. Elytra with distinct false veins in both discoidal and interulnar areas. Pronotum less coarsely punctured. Lateral margins of the fastigium of vertex narrow, scarcely punctured, not impressed. First joint of the hind tarsi with only its base black. Female subgenital plate with the carinae granulate.—S. China, Formosa, India .. .. .. .. .. .. 3. *annulicornis* (Shir.).

6 (1). Male cerci apically obliquely truncate (fig. 2 E), appendiculate (fig. 1 F) or bifurcate (fig. 2 F). Female subgenital plate without any longitudinal carinae. Pronotum smooth or not coarsely punctured.

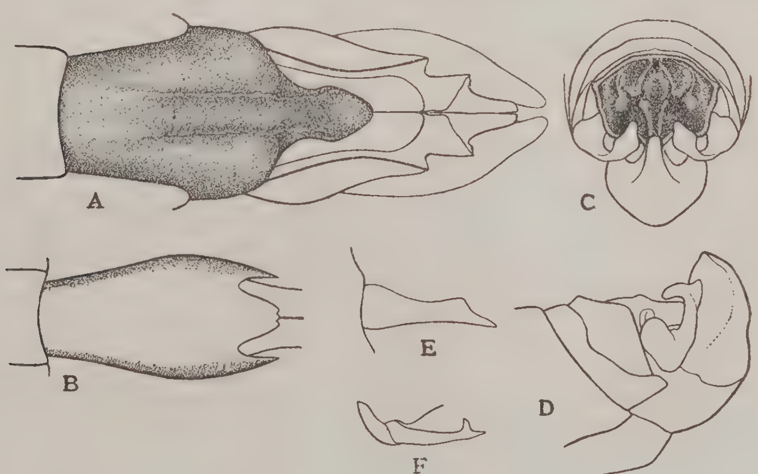


Fig. 2. A, *Hieroglyphus concolor*, Walk., female genitalia from below; B, *Hieroglyphodes assamensis*, g. & sp. n., female subgenital plate from below; C, D, *H. assamensis*, male genitalia; E, *Hieroglyphus nigrorepletus*, Bol., male cercus; F, *H. banian*, F., male cercus.—All figures × 3·5.

7 (8). Male cerci obliquely truncate (fig. 2 E). Pronotum in profile slightly convex or straight; its disc distinctly broadened posteriorly and unicolorous; lateral lobes convex between sulci, which are broadly filled with black; a black line runs along the upper margin of each lobe and the lower ends of the first and third sulcus are also connected by a black line.—India .. .. .. .. .. .. 4. *nigrorepletus*, Bol.

8 (7). Male cerci appendiculate or bifurcate. Pronotum in profile not convex; its disc scarcely widened posteriorly; no black line along the upper margin of its lateral lobes.

9 (12). Male cerci bifurcate (fig. 2 F). Pronotum not at all or scarcely selliform, with the hind sulcus perfectly straight. Head not or only slightly thicker than pronotum and, seen in profile, not strongly prominent above it. Mesosternal interspace not strongly constricted in the middle (fig. 3 C, D).

10 (11). Male cerci with both branches alike, rounded (fig. 2 F). Fastigium of the vertex not longer than broad in the male, transverse in female.—India .. .. .. .. .. .. .. 5. *banian* (F.).

11 (10). Male cerci with the inner branch broad, depressed, truncate. Fastigium of the vertex in the male longer than broad (female unknown).—Tonkin .. .. .. .. .. .. 6. *tonkinensis*, Bol.

12 (9). Male cerci appendiculate (fig. 1 F). Pronotum distinctly selliform. Head distinctly thicker than pronotum and considerably prominent above it; the hind sulcus distinctly arched. Mesosternal interspace strongly constricted in the middle (fig. 3 A).

13 (14). Male subgenital plate distinctly sulcate above, with the apex emarginate (fig. 1 E).—Senegal, N. Nigeria .. .. 7. *daganensis*, Krauss.

14 (13). Male subgenital plate not sulcate, with the apex truncate.—India .. 8. *oryzivorus*, Carl.

1. **Hieroglyphus africanus,** sp. n. (fig. 1 B).

♂. Of medium size for the genus. Front strongly reclinate; its ridge with the sulcus slightly widened in the middle and gradually narrowed towards both the clypeus and the fastigium, which it does not reach, disappearing half-way between the base of antennae and the margin of the fastigium of vertex, so that the uppermost portion of the frontal ridge is not sulcate, slightly convex, punctured. Fastigium of the vertex scarcely sloping, with the bow-shaped transverse sulcus well developed; the portion in front of the sulcus about half as broad again as long, rotundato-pentagonal, with the surface flat and an indistinct longitudinal carinula in front; lateral margins of the fastigium thick, with distinct, obliquely placed, narrow, coarsely punctured temporal foveolae. Pronotum strongly cylindrical, very coarsely punctured; transverse sulci deep and broad, straight on the disc; median keel scarcely perceptible. Mesosternal lobes as long as broad, with the interspace gradually narrowed in the middle. Metasternal lobes contiguous. Elytra without false veins in the discoidal and interulnar areas. Supra-anal plate longer than its basal width, with a median sulcus in its basal half. Cerci not longer than the supra-anal plate, thick, gradually narrowed and slightly decurved posteriorly, with the apex indistinctly obliquely truncate internally. Subgenital plate obtusely conical, short, not longer than its basal width.

Greenish yellow, with the hind tibiae pale green and the following parts black: antennae, except two basal joints; sulci of the pronotum; a transverse fascia on the inner side of the hind femora just before the knee, and a small spot corresponding with it on the outer side; a post-basal ring, the inner side of the apex and points of spines of the hind tibiae; the basal half of the first joint of the hind tarsi, the very base of the second and margins of the pulvillus.

♀ (paratype). Differs from the male in the frontal part of the fastigium of vertex being rounded in front and more than twice as broad as long, and in the lesser development of the black markings, only the last pronotal sulcus being blackened, while the

hind tarsi are marked with brown instead of black ; the head above, metazona of the pronotum and hind femora above, reddish ; hind tibiae faintly bluish. Subgenital plate with the carinae not very distinct, granulate.

| | ♂ (type). | ♀ (paratype). |
|---|---|---|
| Length of body .. .. .. .. | 40 mm. | 54 mm. |
| ,, ,, pronotum .. .. .. | 9? (hind angle broken off) | 13·5 |
| ,, ,, elytra .. .. .. .. | 26 | 32·5 |
| ,, ,, hind femur .. .. .. | 22 | 27·5 |

The type is from Atbara, Sudan (British Museum) ; the paratype from Adamane, Kamerun (Brunner von Wattenwyl's collection in the Wiener Staats-museum).

This new species, unfortunately represented by two specimens only, is very closely related to the Oriental *H. concolor*, from which it is separated by only a few characters of uncertain value. It is not impossible that further study of long series of both species may result in the necessity of uniting them, but I believe that, even in that case, they may be regarded as distinct geographical races (subspecies). The differences between the male and the female of the new species are scarcely more than individual, and I do not hesitate in regarding them as conspecific, which makes the range of distribution of the species to extend right across the subequatorial belt of Africa.

2. **Hieroglyphus concolor** (Walk.) (fig. 2 A).

1870. *Oxya concolor*, Walker, Cat. Derm. Salt. Brit. Mus., iv, p. 646.

1878. *Hieroglyphus tarsalis*, Stål, Bih. Sven. Akad. Handl., v (4), pp. 48, 93.

1893. *Hieroglyphus citrinolimbatus*, Brunner v. Wattenwyl, Ann. Mus. Genova, xxxiii, p. 154.

1910. *Hieroglyphus concolor*, Kirby, Syn. Cat. Orth., iii, p. 397.

1910. *Hieroglyphus citrinolimbatus*, Kirby, *l.c.*, p. 397.

1912. *Hieroglyphus concolor = tarsalis*, Bolivar, Trab. Mus. Madrid, no. 6, p. 54.

1912. *Hieroglyphus citrinolimbatus*, Bolivar, *l.c.*, p. 54.

1914. *Hieroglyphus citrinolimbatus*, Kirby, Fauna Brit. Ind., Acrid., pp. 202, 205.

1914. *Hieroglyphus concolor*, Kirby, *l.c.*, p. 202, 205.

1916. *Hieroglyphus tarsalis*, Carl, Revue Suisse Zool., xxiv, no. 6, pp. 478, 479.

1916. *Hieroglyphus citrinolimbatus* Carl, *l.c.*, pp. 478, 479.

1918. *Hieroglyphus concolor*, Bolivar, Trab. Mus. Madrid, no. 34, p. 22.

1918. *Hieroglyphus tarsalis*, Bolivar, *l.c.*, p. 29.

1918. *Hieroglyphus citrinolimbatus*, Bol., *l.c.*, p. 30.

As I have had the opportunity of comparing cotypes of *H. citrinolimbatus*, Br. Watt., with the types of *Oxya concolor*, Walk., and also of comparing the latter with the good description of *H. tarsalis*, Stål, I do not hesitate in regarding all the three species as identical. The only reason for separating *citrinolimbatus* is that it has the pronotum very narrowly marginated with yellow, which character is, however, obviously of no specific value, since it varies even in the small series of specimens before me.

The general coloration of this species varies from greenish-yellow to brownish-yellow ; the transverse sulci of the pronotum are very narrowly, or not at all, blackened ; the coloration of the hind tarsi (see the key to species) is very characteristic. The size is very variable, as the following dimensions show :—

| | ♂♂ | ♀♀ |
|---|---|---|
| Length of body .. .. | 30–45 mm. | .. 46–60 mm. |
| ,, pronotum .. | 7–10 ,, | .. 13–16 ,, |
| ,, elytra .. | 22–32 ,, | .. 33-45 ,, |
| ,, hind femur .. | 16–22 ,, | .. 25–? ,, |

*Specimens examined.*—N. India, 1 ♂, 1 ♀ (Walker's types; Brit. Museum); Himalaya, 1 ♂, 1 ♀ (cotypes of *H. citrinolimbatus*, Br. Watt.; Wiener Mus.); Sikkim 1, ♂ (named by Brunner v. Wattenwyl as *H. citrinolimbatus*; Wiener Mus.); Kasal Mandvi, Surat, Bombay, 5.x.1903, 1 ♂ (Pusa Coll.).

Other reliable records for this species are Sylhet (typical locality for *H. tarsalis*, St.), and Bhamo, Burma (typical locality for *H. citrinolimbatus*, Br. Watt.); while that from China (Stål, *l.c.*), besides being very indefinite, wants confirmation. Kirby's record from Kanara, Bombay, refers to the next species.

*Economic importance.*—The specimen from Pusa collection taken at Kasal Mandvi, Surat, is labelled "crops," as are also several specimens of *H. oryzivorus* taken simultaneously, so that there is certain reason to suspect this species as a pest. Kirby's suggestion (Fauna Brit. India, p. 205) that it is commoner than *H. banian* is quite inexplicable, since he has not seen more than the two type specimens.

3. **Hieroglyphus annulicornis** (Shir.) (fig. 1 G).

1910. *Oxya annulicornis*, Shiraki, Acrididen Japans, pp. 53, 57, figs. 12 *a*, *b*, *c*.

1910. *Oxya annulicornis*, Matsumura, Ztschr. Wiss. Insektenbiol., vi, Heft 3 25.iii.1910), p. 102 (*nomen nudum* !).

1910. *Oxya annulicornis*, Matsumura, Die Schädl. u. nützl. Insekten vom Zukerrohr Formosas, p. 2, pl. iv, fig. 4 (28.vii.1910).

1911. *Oxya annulicornis*, Matsumura, Mem. Soc. Ent. Belg., xviii, p. 129.

1912. *Hieroglyphus formosanus*, Bolivar, Trab. Mus. Madrid, no. 6, pp. 54, 55.

1913. *Oxya annulicornis*, Matsumura, Thousand Insects of Japan, Addit. i, p. 19, pl. iii, fig. 4.

1916. *Hieroglyphus tonkinensis*, Carl, Revue Suisse Zool., xxiv, no. 6, pp. 478, 479 (*nec H. tonkinensis*, Bol. 1912 !).

1918. *Hieroglyphus annulicornis*, Bolivar, Trab. Mus. Madrid, no. 34, pp. 29.

1918. *Hieroglyphus formosanus*, Bolivar, *l.c.*, p. 29.

Though Shiraki himself has described the insect as *Oxya annulicornis*, Mats. (n. sp.), it appears that he only adopted for it the manuscript name by Matsumura, who twice (1910 and 1911) described it as a new species, but apparently the first of these descriptions was published after that of Shiraki, as the paper of the latter author though marked on the cover 1910, bears on p. 87 the date of 4th May 1909, while Matsumura's first description appeared on 28th July 1910. It is not impossible, of course, that the date quoted from Shiraki refers to the completion of his manuscript, and in this case the question of authorship can be settled only by finding out the exact date of publication of Shiraki's paper, which may be possible in Japan. In the meantime, I adopt the authorship of Shiraki, as Matsumura's description is very incomplete and unsatisfactory.

The species forms a kind of link between two groups, that of *H. concolor* and *H. africanus*, on the one hand, and the rest of the genus on the other, but it belongs obviously to the first group. It is easily recognised by the very long cerci and apically attenuate subgenital plate of the male (fig. 1 G), while the female also may be always identified by the presence of two granulate carinae on its subgenital plate. In the coloration of the hind tarsi it agrees with *H. banian*, but is quite distinct from both this and *H. concolor*, while it occupies an intermediate position between these two species with regard to the puncturation of the pronotum. The series before me is insufficient to judge of the variability of the species in coloration, but so far as it goes, only the hindmost sulcus of the pronotum, and on the disc only, is narrowly filled with black, while the third sulcus is just a little darkened, and the remaining ones are unicolorous with the pronotum. With regard to the dimensions, the Chinese specimens are fairly uniform, but differ in size from both Indian and

Formosan specimens, according to Shiraki's figures; it is not impossible that this difference in dimensions may be characteristic for subspecies, but it cannot be stated definitely until more extensive series are studied. The dimensions of specimens from different localities are as follows:—

| | *W. China.* | | *Formosa (after Shiraki).* | | *India.* |
|---|---|---|---|---|---|
| | ♂ | ♀ | ♂ | ♀ | ♂ |
| Length of body .. | 35 | 49–55 | 40–42 | 61–65 | 41 |
| ,, pronotum .. | 8 | 11·5–12 | 8–8·5 | 12–12·1 | 8·5 |
| ,, elytra .. | 25 | 34–36 | 28–30 | 38–41 | 32 |
| ,, hind femur | 18 | 20–23 | 18–19 | 27·8–28 | 19 |

*Specimens examined.*—Amoy, China, 1 ♀; Chung-King, Sze-Chuen Prov., W. China, 2 ♂♂; Hongkong, 1 ♀; "Can." (probably Kanara, India), 1 ♀ (all in Brit. Museum); Pusa, Bihar, India, 26.vii.1916, 16.vii.1919, 2 ♂♂ (Pusa Coll.).

Other localities whence the species has been recorded are Formosa (Shiraki, Matsumura, Bolivar) and Than Moi, Tonkin (Carl).

*Economic importance.*—According to Matsumura, the species is a pest of sugar-cane in Formosa, damaging also *Canna indica*. No record of its being a pest in India is available, but this may be due simply to insufficient investigations.

4. **Hieroglyphus nigrorepletus**, Bol. (fig. 2 E, 3 B).

1891. ||*Hieroglyphus furcifer*, Indian Museum Notes, ii, p. 30 (partly), figure.

1906. ||*Hieroglyphus furcifer*, Maxwell-Lefroy, Mem. Dep. Agr. India, i, no. 1, pl. x, fig. 8.

1906. ||*Hieroglyphus furcifer*, Maxwell-Lefroy, Ind. Ins. Pests, p. 120 (partly), fig. 138.

1907. ||*Hieroglyphus furcifer*, Maxwell-Lefroy, Mem. Dep. Agr. India, i, no. 2, p. 120, fig. 4.

1909. ||*Hieroglyphus furcifer*, Maxwell-Lefroy, Ind. Ins. Life, p. 87 (partly), fig. 27.

1912. *Hieroglyphus nigrorepletus*, Bolivar, Trab. Mus. Madrid, no. 6, pp. 54, 56.

1914. *Hieroglyphus nigro-repletus*, Coleman, Journ. Bombay N.H. Soc., xxiii, pp. 172–174, plate, figs. 1, 2.

1914. *Hieroglyphus nigrorepletus*, Fletcher, Some S. Ind. Insects, p. 531, fig. 425.

1914. *Hieroglyphus bettoni*, Kirby, Fauna Brit. Ind., Acrid., pp. 202, 203, figs. 118, 119.

1916. *Hieroglyphus vastator*, Carl, Revue Suisse Zool., xxiv, no. 6, pp. 478, 479, 481.

1918. *Hieroglyphus nigrorepletus*, Bolivar, Rev. R. Acad. Cien. Madrid, xvi, seg. ser., p. 397.

1918. *Hieroglyphus nigrorepletus*, Bolivar, Trab. Mus. Madrid, no. 34, p. 29.

This is undoubtedly the most easily recognisable species of the whole genus, and there is no excuse for the existing confusion regarding it in the economic and systematic literature. Especially noteworthy is the peculiar shape of the pronotum, as well as the coloration of the latter, not to mention the shape of the male cerci (fig. 2 E). The numerous figures of this species existing in the Indian literature, and quoted above, render its identification very easy, provided that the necessary corrections in accordance with the foregoing quotations are made in the legends to the figures.

The species is liable to considerable individual variation which, however, does not affect its principal characteristics. First of all, there are two distinct forms of the species with regard to the development of the elytra and wings. In the brachypterous form (f. *brachyptera*, Bol.) the elytra are scarcely longer than half the abdomen, and the wings are rudimentary; while the macropterous form has the elytra extending well beyond the apex of the abdomen and the wings perfectly

developed. The macropterous form seems to be far less common than the brachypterous one, and I am inclined to think that the latter is typical for the species, and that macropterism occurs only incidentally as an atavistic mutation, the ancestral form having been, no doubt, macropterous. It is quite remarkable that there are no intermediate forms between the two extremes.

As regards the variability of this species in other respects, there are the usual differences in this genus in the general coloration, which may be either more green, or more brown ; it is not impossible that a change of the general coloration may occur during individual life, as is known for several species of locusts.

The characteristic black design of the pronotum is also variable to a certain extent. In the most richly marked specimens, there is a thick black fascia along the upper margin of the lateral lobes, while another fascia connects the lower ends of the first and the second sulci, which, together with the hindmost one, are also broadly marked with black. It is very characteristic for the species that the sulci on the disc of the pronotum are never black, except in some most heavily marked specimens, in which they may be somewhat blackened laterally, adjoining the lateral fascia, but never for their whole length. The black vertical marks on the lateral lobes may disappear more or less completely, but the longitudinal fasciae are very constant and, even when the whole lobe is unicolorous, there may be detected a trace of a fascia, in the form of black spots in the sulci along the upper margin of the lobe.

The extent of variations in size is also not inconsiderable, as the following table of dimensions shows :—

| | ♂♂ | | ♀♀ |
|---|---|---|---|
| Length of body .. .. .. .. | 30–42 | .. | 38–48 |
| ,, pronotum .. .. .. | 7·5–10 | .. | 8–12·5 |
| ,, elytra in the macropterous form .. .. .. | 31–37 | .. | 39 |
| ,, elytra in the brachypterous form .. .. .. | 12–16 | .. | 10–16 |
| ,, hind femur .. .. .. | 17·5–20 | .. | 16·5–26 |

*Geographical distribution.*—The distribution of this common insect in India is by no means sufficiently known, but the available information, gathered both from literature and from collections, seems to indicate that it is a more southern species, which is widely spread over the Indian peninsula and hardly reaches further north than Allahabad and Pusa ; Kirby's record from Assam (Cachar) is incorrect, as it refers to two insects in the British Museum which are described in this paper as *Hieroglyphodes assamensis*. I do not think it necessary to give a detailed list of localities whence the species is known.

*Economic importance.*—Although in all the earlier records this species is confused with others, under the name of *H. furcifer*, in some cases it is not difficult to make an exact identification of the species from the figures. Thus, it was *H. nigrorepletus* which, possibly in company with some other species, caused damage to rice and other crops in some parts of the Bombay Presidency and of the Central Provinces in 1890, as the insect figured in Vol. ii of the Indian Museum Notes (p. 30) unmistakably represents this species. It seems also that Saussure, to whom specimens collected in 1889 were sent for identification (*l.c.* i, p. 203), intended to describe this species as new, under the name of *H. cotesiana*, which, however, he never did ;* and it is not improbable that *H. vastator* of Carl is based upon one of Saussure's intended types of *H. cotesiana*.

Later on, Maxwell Lefroy (see the references under synonymy), who never separated *H. nigrorepletus* from *H. banian* ( =*furcifer*), gave some rather indefinite records on their joint activities as pests of rice and some other crops ; the actual status of each

* H. M. Lefroy's statement (Indian Ins. Life, p. 87) that "a species (*H. cotesii*)" was described obviously refers to this case and is incorrect.

species cannot, of course, be ascertained from these records. T. B. Fletcher (S. Ind. Insects. p. 531) was first to record this species under its proper name, as a minor pest of *Andropogon sorghum* and *Setaria italica* in Madras. The Proceedings of the Second Entomological Meeting at Pusa, repeat the same information (pp. 181, 201), while in those of the Third Meeting (p. 308) the species is recorded also from rice.

The Pusa collection contains some specimens labelled as actually taken on various crops, and these add maize to the list of plants attacked by *H. nigrorepletus* (Dohad, Bombay, 8.ix.03) ; while there are also fairly long series of specimens from Allahabad, United Provinces, 29.vii.1910, and Partabgarh, Un. Prov., 16.ix.1909, and some other localities, but without more precise information as to the crops affected.

This scanty information seems to indicate that *H. nigrorepletus*, though common enough, is hardly a serious pest of rice and is probably more closely connected with the crops growing under less moist conditions, such as *Setaria* and *Andropogon*. The bionomics of this species may therefore be considerably different from those of *H. banian*, at least as regards its habitat.

**5. Hieroglyphus banian** (F.) (figs. 1 A, 2 F, 3 C, 3 D).

1798. *Gryllus banian*, Fabricius, Entom. System., Suppl., p. 194.
1839. *Acridium furcifer*, Serville, Ins. Orthopt., p. 677, pl. 14, fig. 12.
1842. *Oxya furcifera*, De Haan, Temminck, Verhand., Orthopt., p. 155.
1891. *Hieroglyphus furcifer*, Indian Museum Notes, ii, p. 30 (partly, but not the figure !).
1906. *Hieroglyphus furcifer*, Maxwell-Lefroy, Ind. Ins. Pests, p. 119 (partly), fig. 137.
1907. *Hieroglyphus furcifer*, Maxwell-Lefroy, Mem. Dep. Agr., India, i, no. 2, p. 120 (partly), fig. 3.
1909. *Hieroglyphus banian*, Maxwell-Lefroy, Ind. Ins. Life, p. 87 (partly), pl. vii.
1910. *Hieroglyphus banian*, Kirby, Synon. Cat. Orth., iii, p. 396.
1911. *Hieroglyphus banian*, Coleman & Kuhni Kannan, Dept. Agric. Mysore, Entom. Ser., Bull. No. 1.
1912. *Hieroglyphus banian*, Main, Agric. Journ. India, vii, p. 246, pl. xxx.
1912. *Hieroglyphus banian*, Bolivar, Trab. Mus. Madrid, no. 6, p. 53.
1914. *Hieroglyphus banian*, Kirby, Fauna Brit. Ind., Acrid., p. 202, 204.
1914. *Hieroglyphus banian*, Fletcher, S. Ind. Ins., p. 531, pl. 1, figs. 1, 2, 3.
1916. *Hieroglyphus furcifer*, Carl, Rev. Suisse Zool., xxiv, no. 6, pp. 478, 479.
1918. *Hieroglyphus banian*, Bolivar, Rev. R. Acad. Cien. Madrid, xvi, seg. ser., p. 396.
1918. *Hieroglyphus* sp., Bolivar, ., *l.c.*, p. 397.
1918. *Hieroglyphus banian*, Bolivar, Trab. Mus. Madrid, no. 34, p. 28.

Some slight doubts that existed concerning the identity of *Gryllus banian*, F., and *Acridium furcifer*, Serv., on account of the first-named species having been described from a female only and very insufficiently, have been dispelled after my examination of one of the original cotypes of the Fabrician species.

With regard to the individual variability of this species, which I have been able to study in a very long series of specimens, it can be positively stated that the assumption made by Lefroy in all his books (see references under synonymy) that it occurs in both macropterous and brachypterous forms, is incorrect and due to the confusion of *H. banian* with *H. nigrorepletus*. This fact was first established by Coleman (Jl. Bombay Nat. Hist. Soc., xxiii, 1914, p. 172), who distinguished *H. nigrorepletus* from *H. banian* and sent it to Bolivar for description.

The extensive series of this species studied by me may be divided into two sufficiently well defined groups. One consists of the insects of smaller average size, with

the fastigium of the vertex shorter, the pronotum with the sulci black, and the metazona more coarsely punctured than in the other group; this is systematically the typical form of the species, since the cotype of *Gryllus banian*, F., studied by me belongs here. The other group, which I propose to regard temporarily (see below) as a variety, may be characterised as follows :—

Var. **elongata**, nov. (fig. 3 C). Distinctly larger and more slender than the typical form. Face more reclinate. Fastigium of the vertex in the male distinctly widened anteriorly, its portion in front of the transverse impression slightly longer than its maximum width. Pronotum unicolorous, with the transverse sulci just slightly darkened, but not black. Mesosternal interspace in the male strongly narrowed in the middle, where it is not half as broad as anteriorly or posteriorly (compare figures 3 C and 3 D); hind margins of the mesosternal lobes oblique in relation to the median line. Male cerci slightly more incurved than in the typical form. In the female (paratype) the mesosternal interspace is also distinctly constricted in the middle, though less so than in the male, its minimal width being subequal to one-half of the maximal (in the typical form the mesosternal interspace of the female is very feebly constricted); the mesosternal lobes are about as long as broad, while in the typical form they are decidedly transverse.

The type of the new variety is from Faridpur, Bengal, 30.viii.1909, whence come also two male and five female paratypes; further paratypes are from Cuttack, Bengal, 23.xi.1905, 5 ♂♂; Khurda, ii.xi.1913, 8 ♀♀; Shahganj, United Provinces, 9.xi.1904, 6 ♂♂; Pusa, Bihar, various dates, 1 ♂, 4 ♀♀; Goalundo-Gauhati, Brahmaputra River, vii.1919, 1 ♀; 1 ♂ from India, without locality.

Dimensions of the typical form and of the new variety are as follows :—

| | Typical form. | | Var. *elongata*. | |
|---|---|---|---|---|
| | ♂♂ | ♀♀ | ♂♂ | ♀♀ |
| Length of body .. | 28–34 | 34–44 | 35–44 | 40–54 |
| ,, ,, pronotum .. | 5–6 | 6–9 | 6·5–8 | 8–10 |
| ,, ,, elytra .. | 20–27 | 24–34 | 27–34 | 32–43 |
| ,, ,, hind femur .. | 15–16·5 | 18–22 | 18–20·5 | 24–28 |

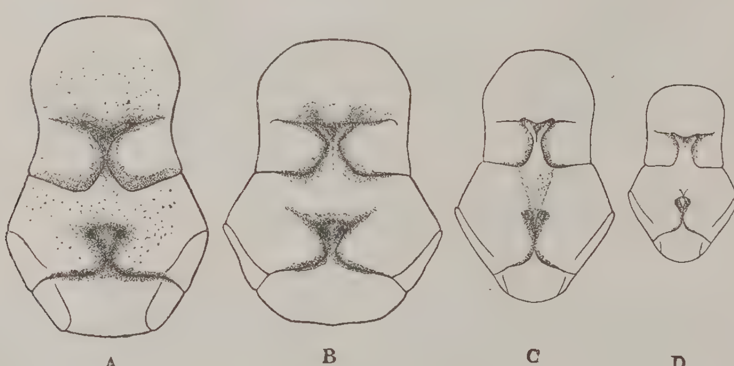


Fig. 3. Sternum of different species of *Hieroglyphus*: A, *H. daganensis*, Kr., ♀; B, *H. nigrorepletus*, Bol., ♀; C, *H. banian*, F., var. *elongata*, nov., ♂; D, *H. banian*, F., typical form, ♂.—All figures ×4.

There is no doubt that the *Hieroglyphus* sp. mentioned by Bolivar (Rev. R. Acad. Cien. Madrid, xvi, p. 397, no. 79) and briefly described by him without a specific name is our var. *elongata*. The typical series of this variety from Faridpur has been also mentioned as distinct from the typical form by Fletcher (Proc. Third Entom. Meeting at Pusa, p. 309).

The exact relation of the var. *elongata* to the typical form is uncertain. I cannot regard it as distinct specifically, in spite of the important differences in the mesosternum, because there are before me some specimens which are transitional between the two forms in this respect; there are also clear transitions in other characters, notably in the coloration of the pronotum, which often has blackened sulci in specimens morphologically identical with var. *elongata*. The most interesting point is that different lots of specimens, each including only individuals taken in the same locality and on the same date, exhibit a remarkable constancy of characters in each lot, and a not less remarkable difference in the complex of characters from other lots. Thus a long series of specimens from Pusa, vi.1908, represent most typical examples of *H. banian*; another series from the same locality, vi.1906, consists of specimens also typical, but on the average somewhat larger; all insects from Ballia, Bengal, 14.ix.1907, on sugar-cane, are of about the same size as the previous lot, but decidedly more slender; specimens from South Mysore, ix.1903, are as large as var. *elongata*, and with the sulci of the pronotum hardly blackened, but heavily built and in the structure of mesosternum nearer to the typical form; the Faridpur series of var. *elongata* consists of specimens decidedly larger than that from Cuttack, or from Khurda; specimens of the latter series are also remarkable by the more saddle-shaped pronotum; while all specimens from Shahganj, though agreeing in all respects with var. *elongata*, show distinctly blackened sulci; and so forth. These facts suggest that *H. banian* is a species which is liable to considerable variations, probably, in connection with some peculiarities of local and seasonal conditions, and the var. *elongata* is only an extreme form, connected with the opposite extreme by transitions. If this suggestion is correct (which may be proved by an extensive study of very long series of specimens collected in various localities and in the same locality in different years, on the one hand, and by breeding experiments under different conditions on the other), then var. *elongata* and other minor varieties may be regarded as morphae, or ecological forms; but in the meantime the indefinite term "variety" is preferable. The study of the variability of *H. banian* may prove to be of great economic importance, as it is not impossible that periodical increases in the number of these grasshoppers leading to an invasion of crops, are connected with morphological variations of the insect, as is the case with some of the swarming locusts.*

*Geographical distribution.*—*H. banian* is, probably, the most common of the species of this genus in India and distributed all over the plains, but the north-western, northern and north-eastern limits of its area are yet very inadequately known; it seems that it does not extend either into the north-western provinces or into Assam, though the lack of records from these parts may be due simply to the fact that these insects have not been searched for there. I think it needless to give here a complete list of localities.

*Economic importance.*—The bionomics of this species are fully described in the valuable bulletin of Coleman and Kuhni Kannan (see reference under synonymy). The chief plants affected during its invasions are rice and sugar-cane, but other crops, such as sorghum, maize, or *Setaria*, as well as grasses, are also eaten.

6. **Hieroglyphus tonkinensis,** Bol.

1912. *Hieroglyphus tonkinensis*, I. Bolivar, Trab. Mus. Madrid, no. 6, p. 54.

1918. *Hieroglyphus tonkinensis*, I. Bolivar, *l.c.*, no. 34, p. 29.

This species must not be confused with *H. tonkinensis* of Carl, described in 1916, which is conspecific with *H. annulicornis*, Shir. (see above).

The principal difference of this species, of which the type and only known specimen has been studied by me, from *H. banian* consists in the shape of the male cerci, as the other characters given by Bolivar are not constant in *H. banian* as I have already

* See my paper on the genus *Locusta* with a theory of the periodicity of locusts, in Bull. Ent. Res., xii, 1921, pp. 135–163.

shown. As regards the cerci, the difference is also somewhat doubtful, as the type of *H. tonkinensis* has only the right cercus left, and its shape may be due to malformation of the inner tooth following some injury to it during moulting. Since, however, no specimens of *H. banian* are known from Tonkin, or from China in general, I prefer to keep *H. tonkinensis* separate until further material is available.

The type is from Hanoi, Tonkin.

8. **Hieroglyphus daganensis,** Krauss (fig. 1 F, 3 A).

1877. *Hieroglyphus daganensis*, Krauss, Sitz. Akad. Wiss. Wien, lxxvi (i), p. 42, pl. i, fig. 6.

1878. *Hieroglyphus daganensis*, Stål, Bih. Sven. Akad., v (4), p. 93.

1910. *Hieroglyphus daganensis*, Kirby, Syn. Cat. Orth., iii, p. 396.

1910. *Hieroglyphus daganensis*, I. Bolivar, Trab. Mus. Madrid, no. 6, p. 53.

1916. *Hieroglyphus daganensis*, Carl, Rev. Suisse Zool., xxiv, no. 6, pp. 478, 479.

1918. *Hieroglyphus daganensis*, I. Bolivar, Trab. Mus. Madrid, no. 34, p. 28, no. 1.

This species and the very closely related *H. oryzivorus* form a somewhat aberrant group within the genus, but I see no reason for separating them off, as the principal characters which may be considered of generic value are sufficiently uniform throughout all species included in it.

*H. daganensis* is remarkable for its very pale greenish coloration, with the hind femora straw-coloured on the outer side and more or less reddish below ; hind tibiae pale blue ; black marks on the lateral lobes of pronotum very sharp, the first and third sulcus being connected by a black line below, while the sulci on the disc are unicolorous.

Both macropterous and brachypterous forms are known ; the former seems to be more common than the latter, which is known in the female sex only and has been named by Krauss var. *abbreviata*.

The dimensions are as follows :—

| | ♂♂ | | ♀♀ |
|---|---|---|---|
| Length of body .. .. .. .. | 40–41 | .. | 47–58 |
| „ pronotum .. .. .. | 8–8·5 | .. | 9–11 |
| „ elytra in macropterous form | 31–32 | .. | 34–40 |
| „ „ brachypterous form | unknown | .. | 20–22 |
| „ hind femur .. .. .. | 19–20 | .. | 21–25 |

*Geographical distribution.*—Originally described from Dagana, Senegal. I have studied 2 ♂♂ and 8 ♀♀ of the macropterous form from Argungu, N. Nigeria, 21.x.1910, and one female of f. *abbreviata* from Tuburi Marsh, French Central Africa, in the British Museum.

8. **Hieroglyphus oryzivorus,** Carl.

1916. *Hieroglyphus oryzivorus*, Carl, Rev. Suisse Zool., xxiv, no. 6, pp. 478, 479, 480.

This species is very intimately related to *H. daganensis*, the only significant difference between them being in the shape of the male subgenital plate, and this may prove to be not quite constant when longer series are studied. There seems to be, however, a more or less constant difference in the dimensions, *H. oryzivorus* being smaller on the average, and I think it may justify, when the distribution of both species is taken into consideration, at least their subspecific separation ; in the meantime, and especially for the practical purposes of economic entomologists, it may be more convenient to treat them as separate species.

Carl described the species from two females only and he felt inclined to attribute to it the male figured by Lefroy (Mem. Dept. Agr. India, i, no. 1, pl. viii, fig. 4, pl. x, fig. 8) under the name of *H. furcifer*. There is no doubt, however, that fig. 8 of pl. x represents the male genitalia of *H. nigrorepletus*, as has been indicated under that

species, while fig. 4 of pl. viii seems to me more like *H. banian* than *H. oryzivorus*. As I have before me several lots of the latter species, taken in different localities, in both sexes, there is no doubt whatever that the hitherto unknown males of it are named by me correctly, and the astonishing likeness of *H. oryzivorus* to *H. daganensis*, which attracted Carl's attention, becomes still more remarkable.

*H. oryzivorus* may be at once recognised amongst other Indian species by its saddle-shaped pronotum, but especially and more surely by the shape of the hind sulcus of the disc which is distinctly bow-shaped, with the convexity directed forwards, in this species, and perfectly straight in all the other species ; this character is less conspicuous in the males owing to their small size, but the shape of the male genitalia, which are quite like those of *H. daganensis* (fig. 1 F) apart from the difference in the subgenital plate above referred to, renders a mistake out of the question. A minor, but very constant, feature of the coloration of *H. oryzivorus* is the complete lack of any black markings on the hind knees, tibiae and tarsi, except the black points of the tibial spines. Black markings on the pronotum may be more or less obliterated, but even in the most richly marked specimen the sulci are black on the lateral lobes only and never on the disc of the pronotum.

The dimensions are fairly variable, as may be seen from the following table :—

| | | ♂♂ | | ♀♀ |
|---|---|---|---|---|
| Length of body .. | .. .. .. | 29–36 | .. | 43–52 |
| ,, pronotum | .. .. .. | 5–6·5 | .. | 7·5–10 |
| ,, elytra of macropterous | form | 21–24 | .. | 34–40 |
| ,, ,, brachypterous | form | unknown | .. | 16–25 |
| ,, hind femur | .. .. .. | 16–17 | .. | 19–24 |

As it is obvious from the table, *H. oryzivorus* occurs in both brachypterous and macropterous form, though the latter seems to be rare in the female sex, while, on the other hand, the only two known males are both macropterous.

*Geographical distribution.*—This species was originally described from Murshidabad (in Bengal) and " Bilaspia, Indes centrales," which is probably Belaspur in the Central Provinces. The specimens from the Pusa collection studied by me are mostly from the Bombay Province : Pardi, 23.ix.1904 ; Khurda, 11.xi.1913 ; Kasal-Mandvi, 25.x.1903 ; Jhalod, Panch Mahals, 9.xi.1903 ; some are from the Central Provinces, Raipur, 13.x.1903 ; Mungeli, Belaspur, 25.x.1906 ; in the Coimbatore collection there are also specimens from S. India, so that the species seems to be fairly widely distributed throughout the Indian plains.

*Economic importance.*—Carl's original description was based upon two females, one of them labelled : " *Pha-pha* ; détruit le riz dans le district de Bilaspia, Indes centrales " and the series before me from Raipur is also labelled as taken from rice, while that from Kasal-Mandvi bears the label " crops." There is, therefore, no doubt that this species, alone or accompanied by others (*banian*, *nigrorepletus*, *concolor*), is destructive to rice and some other crops, but the exact economic status of each one of them remains yet to be studied on the spot, and I hope that this paper will render this problem easier than it used to be.

## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st April and 30th June 1922, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. A. Andrews :—545 Coleoptera ; from Assam, India.

Dr. G. Arnold :—114 Coleoptera ; from South Africa.

Dr. G. Babault :—82 Orthoptera ; from India and Kashmir.

Mr. E. Ballard, Government Entomologist :—226 Hymenoptera, 59 Coleoptera, and 7 Rhynchota ; from South India.

Mr. C. F. C. Beeson, Forest Zoologist :—15 Chalcids ; from India.

Mr. C. E. Bellamy :—2 Orthoptera ; from the Canary Islands.

Mr. H. E. Box, Assistant Entomologist :—2 Diptera, 650 Hymenoptera, 323 Coleoptera, 15 Lepidoptera, 37 Rhynchota, and 42 Orthoptera ; from Kenya Colony.

Dr. C. K. Brain :—2 Culicidae, 6 Tabanidae, 39 other Diptera, 16 Hymenoptera, 152 Coleoptera, 42 Rhynchota, 92 Orthoptera, and 8 Planipennia ; from South Africa.

Mr. G. E. Bryant :—1,454 Coleoptera ; from North America.

Mr. P. A. Buxton :—60 Culicidae, 10 Tabanidae, 135 other Diptera, 548 Coleoptera, 80 Lepidoptera, 6 Cimicidae, 3 species of Coccidae, 18 other Rhynchota, and 184 Orthoptera ; from Palestine.

Mr. G. H. Corbett, Government Entomologist :—79 Diptera and 3 pupa-cases, 34 Hymenoptera and 2 pupa-cases, 151 Coleoptera, 81 Lepidoptera and 5 early stages, 58 Rhynchota, and 191 Orthoptera ; from the Federated Malay States.

Mr. E. Cresswell-George :—5 Coleoptera, 7 Rhynchota, and 7 Orthoptera ; from Nyasaland.

Dr. A. Cros :—111 Orthoptera ; from Algeria.

Mr. M. T. Dawe :—1 *Tabanus*, 4 *Glossina*, 20 *Stomoxys*, 1 *Auchmeromyia*, 34 Coleoptera, and 1 species of Coccidae ; from Portuguese West Africa.

Director of Veterinary Education and Research, Pretoria (per H. H. Curson) :—64 Siphonaptera, 2 Culicidae, 11 Tabanidae, 8 *Glossina*, 16 *Stomoxys*, 31 Hippoboscidae, 425 other Diptera, 25 Oestrid larvae, 142 other Dipterous larvae, 160 Hymenoptera, 122 Coleoptera and 12 larvae, 43 Lepidoptera, 15 Rhynchota, 83 Orthoptera, 100 Isoptera, 3 Ephemeridae, 3 Odonata, 39 Anoplura, 19 Mallophaga, 874 Ticks, 74 Mites, 3 Spiders, 3 Centipedes, 5 Millipedes, a number of intestinal worms, and 2 Wood-lice ; from Zululand.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist :—157 Orthoptera ; from India.

C. C. Gowdey, Government Entomologist :—13 Diptera, 8 Hymenoptera, 6 Coleoptera, 6 Lepidoptera, 5 species of Coccidae, and 7 other Rhynchota ; from Jamaica.

Mr. E. E. Green :—370 Orthoptera ; from Ceylon.

Mr. C. B. Hardenberg, Government Entomologist :—1,465 Coleoptera ; from Portuguese East Africa.

Mr. H. Hargreaves, Government Entomologist :—5 Siphonaptera, 3 *Simulium*, 12 other Diptera, 1,072 Hymenoptera, 316 Coleoptera, 50 Lepidoptera, 1 species of Aleurodidae, 7 Cimicidae, 7 species of Coccidae, 688 other Rhynchota, 72 Isoptera, 3 Planipennia, 2 Odonata, 17 Ticks, a number of Mites, 6 Spiders, 2 Pseudo-scorpions, and 2 Tubes of Intestinal Worms ; from Uganda.

Mr. G. F. Hill, Entomologist, Australian Institute of Tropical Medicine:—43 Culicidae and 3 Culicid preparations, 7 Tabanidae, 2 *Lyperosia*, 12 Coleoptera, 4 Hymenoptera, 10 Lepidoptera, and 4 Rhynchota; from North Queensland.

Mr. G. V. Hudson:—128 Parasitic Hymenoptera; from New Zealand.

Mr. M. Afzal Hussain, Government Entomologist:—8 Diptera, 107 Parasitic Hymenoptera, and 30 Rhynchota; from the Punjab.

Mr. J. C. Hutson, Government Entomologist:—33 Moths and 2 Cocoons; from Ceylon.

Dr. W. B. Johnson, W.A.M.S.:—12 Tabanidae, 12 *Glossina*, a large number of puparia of *Glossina tachinoides*, 3 Hymenoptera, a tube of Mites from ears of monkey, and 25 Leeches; from Northern Province, Nigeria.

Mr. P. R. Lowe:—2 Orthoptera; from France.

Dr. J. W. Scott Macfie:—124 Siphonaptera, 130 Culicidae, 15 Culicid larvae, 16 Tabanidae, 12 *Glossina*, 12 Psychodidae and 14 early stages, 239 other Diptera, 100 Coleoptera, 15 Hymenoptera, 17 Lepidoptera, 39 Rhynchota, 1,000 Anoplura, 26 Mallophaga, 266 Ticks, a number of Mites, 3 Scorpions, 7 Millipedes, and 2 Spiders; from the Gold Coast.

Prof. S. A. Mokrzecki:—4 Diptera and 2 Braconidae; from Poland.

Mr. J. C. Moulton:—2 Hymenoptera, 18 Coleoptera, 7 Rhynchota, and 2 Orthoptera; from Singapore.

Museum d'Histoire Naturelle, Geneva:—47 Orthoptera; from various localities.

Museum National d'Histoire Naturelle, Paris:—101 Orthoptera; from various localities.

Natal Museum:—2 Orthoptera; from Natal.

Mr. W. H. Patterson, Government Entomologist:—18 Coleoptera; from the Gold Coast.

Mr. A. W. J. Pomeroy, Government Entomologist:—20 Diptera, a number of Chalcids and early stages, 250 other Hymenoptera, 135 Coleoptera, 57 Lepidoptera and 3 early stages, and 20 Rhynchota; from Southern Province, Nigeria.

Mr. A. H. Ritchie, Government Entomologist:—13 Diptera, 131 Coleoptera, 10 species of Coccidae, 2 species of Aphididae, and a number of Thrips; from Tanganyika Territory.

Section of Entomology, Anglo-Egyptian Sudan:—6 *Tabanus*, 5 *Haematopota*, 121 other Diptera, 4 Oestrid larvae, 121 Hymenoptera, 226 Coleoptera, 5 Lepidoptera, 9 Orthoptera, and 2 Intestinal Worms; from the Anglo-Egyptian Sudan.

Mr. H. W. Simmonds:—1 *Tabanus*, 75 other Diptera, 10 Hymenoptera, 46 Coleoptera, 7 Lepidoptera, 2 Trichoptera, 18 Rhynchota; from Fiji Islands.

Mr. C. Smee, Government Entomologist:—44 Coleoptera and 6 early stages, 26 Rhynchota, and 2 Spiders; from Nyasaland.

Mr. R. Swainson-Hall:—1 *Goliathus giganteus*, Lam.; from British Cameroons, West Africa.

Dr. R. J. Tillyard:—1 species of Aphididae; from New Zealand.

Mr. R. Veitch:—3 Diptera, 33 Hymenoptera, 23 Coleoptera, 73 Lepidoptera, 11 Rhynchota, 27 Orthoptera; from Fiji Islands.

Wellcome Bureau of Scientific Research:—2 Diptera, 1 Sphegid, 5 Coleoptera, 7 Orthoptera, and 20 Spiders; from Peru.

Prof. H. H. Whetzel:—6 Coleoptera; from Bermuda.

Mr. G. N. Wolcott:—2 Coleoptera; from New York, U.S.A.

# AN ATTEMPT TO INTRODUCE SCOLIID WASPS FROM MADAGASCAR TO MAURITIUS.

By D. d'Emmerez de Charmoy,

*Assistant Director and Entomologist, Department of Agriculture, Mauritius.*

(Plates VI–IX.)

Attention was first directed to the Scoliid wasps of Madagascar in 1916, in which year it became clear that further attempts at importing *Tiphia parallela* from Barbados to Mauritius for the control of *Phytalus smithi* would have to be abandoned on account of difficulties of transport arising out of the war. The establishment of *Tiphia* in Mauritius shortly afterwards caused this question to lose its urgency, but in the meantime the attention of the writer had been attracted by a footnote in a paper by de Saussure* regarding *Oryctes simiar* and its natural enemy *Scolia oryctophaga*, the habits of which had been studied by Dr. Ch. Coquerel during his stay in Madagascar in the year 1850.

In Mauritius *Oryctes tarandus*, locally known as the Gros Moutouc, had for some years been responsible for considerable damage to growing canes, and it seemed possible that the Scoliids might be capable of effecting some control thereon. After discussion with the Government and the planters it was decided that the attempt to introduce these insects into Mauritius should be made, and accordingly the writer, accompanied by Mr. S. Gebert, Scientific Assistant in the Biological Division of the Department of Agriculture, was delegated to proceed to Madagascar in May 1917 with this object in view, the necessary funds and assistance being provided by the Government and the planters of the Colony. In the following pages an account is given of the expedition in question and the results which have been recorded in consequence.

## The Habits of Scoliids.

Data gathered by the writer while studying the habits of local species, and also in connection with importations from various foreign sources, have demonstrated many difficulties which attend work of this description, and have emphasised the importance of detailed knowledge respecting the habits and customs of insects that it is proposed to utilise as auxiliaries for the control of insect pests ; nine times out of ten the cause of failure in such undertakings is due to lack of this.

It would seem that parasitism by Scoliids was observed for the first time by the Italian entomologist Passerini,† who pointed out, in 1840 and 1841, that *Oryctes nasicornis* was parasitised by *Scolia flavifrons* and *S. hortorum*. In 1854 Coquerel,‡ in a report to the Société Entomologique de France (to which we shall have to refer again), deals with two other Scoliids of Madagascar, *S. oryctophaga* and *S. carnifex*, parasitic upon *O. simiar*, *O. ranavalo*, and *O. radama*, the habits of which he studied in Madagascar, at Nossi-Bé and Ste Marie, where he had spent several years.

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* " Histoire Physique, Naturelle et Politique de Madagascar," publiée par Alfred Grandidier ; " Hist. Naturelle des Hymenoptères," par H. de Saussure, pp. 188–192.

† " Osserv. sulle larve, ninfe e abitudini della *Scolia flavifrons* " (Pise, 1840) and " Continuazione delle osservazione l'anno 1841 sulle larve di *Scolia flavifrons* " (Firenze, 1841).

‡ " Observations entomologiques sur des insectes recueillis à Madagascar, 4ème partie," par Dr. Ch. Coquerel (Ann. Soc. Ent., France, (3) iii).

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The work of these two entomologists was more recently supplemented by that of J. H. Fabre, though his observations were not concerned with *Oryctes*, but with CETONIIDAE, viz., *Cetonia aurata*, *C. morio*, and *C. floricola*, which are parasitised by *S. bifasciata*; and with *Anoxia villosa* and *A. matutinalis*, parasitised by *S. interrupta*. Although these observations bore almost entirely on the larval development of the Scoliids, they are not devoid of interest from an economic standpoint, as they show clearly that parasitism by Scoliids is not exclusively specific, but is rather generic, since a definite species of Scoliid can parasitise indifferently hosts that are specifically different, while the same host can be parasitised equally well by Scoliids of different species.

Kindred observations made by Nowell* in Barbados in 1915 and by the writer in 1917† showed that in certain cases the tendency to variation in parasitism can even go beyond the limits of genera. Nowell's observation was in relation to *Campsomeris dorsata*, which, although it is normally parasitic on *Ligyrus tumulosus*, is capable, nevertheless, of parasitising *Phytalus smithi* in the very low proportion of 1 per cent.; while in 1917 the writer showed that *Tiphia parallela* in captivity can parasitise *Adoretus versutus* and young larvae of *Oryctes tarandus*.

These facts, which show the extent to which the habits of Scoliids may vary, are recorded here owing to their importance in relation to the problem of importing from a foreign country parasites of unknown habits for the purpose of acclimatising them in another country where a host of a different species, smaller in size and with different habits, had to be substituted for their natural host.

### The Search for Scoliids in Madagascar.

In the investigations the first point requiring to be elucidated was to ascertain whether *S. oryctophaga* was capable of parasitising *O. tarandus* at all. The difference in size between the larvae of the latter and those of the Madagascar species (which reach 7·5 cm. in length, whilst those of *O. tarandus* only attain 5 cm.) was not the only doubtful point. There remained to be considered differences in habits of the larvae, the Madagascar species living exclusively in trunks of trees undergoing decomposition, whilst those of *O. tarandus*, though sometimes met with under the same conditions, are generally found in the soil amidst the root system of sugar-cane plants, at depths varying from 8 to 18 in.

As *O. tarandus* does not exist in Madagascar, arrangements were made for the transport of larvae of this species from Mauritius to Madagascar for experiments.

Coquerel's account indicated Ste Marie and Nossi-Bé as the localities where these investigations might best be carried on, but it was found more convenient to make a beginning in the province of Tamatave, since the locality provided greater facilities for shipment to Mauritius.

Up to 29th June no satisfactory results had been obtained in searching for adult Scoliids. At that time an opportunity occurred of proceeding speedily to the island of Ste Marie, and in view of the negative results obtained so far it was decided to try Ste Marie, and then Nossi-Bé, if necessary. This resolution had hardly been made when *Scolia oryctophaga* were unexpectedly found at Tanamakoa village, not more than 3 km. from the town of Tamatave, so that the conclusion that this species did not exist at Tamatave in sufficient numbers to justify a longer stay in this province required to be modified.

The sudden unexpected presence of these Scoliids in Tanamakoa, a village through which we passed every day, was somewhat perplexing, and at first inclined one to abandon the idea of proceeding to Ste Marie; however, by visiting the same place

* Annals of Applied Biology, ii, no. 1, May 1915.

† Bull. Ent. Research, iii, pt. 1, Aug. 1917; reprinted in Bulletin form by the Department of Agriculture, Mauritius.

and its surroundings on the succeeding days, we satisfied ourselves that we had captured all the Scoliids attracted by the eucalyptus flowers on which we had detected them. The question presented itself to our minds, whether the absence of these Scoliids from all the localities hitherto visited could be attributed to the fact that the season was not the one during which the insect exists in the adult stage, or whether it was to be ascribed to the absence from those localities of these special flowers, which these insects visit by preference.

To explain their sudden appearance in limited numbers in this village it was reasonable to suppose them to have sedentary habits tending to keep them clustered within a limited area, as well as an extraordinary capacity of flight enabling them to seek for their favourite flowers at long distances, and in this way to be present in numbers wherever these flowers are to be found. These hypotheses were quite reasonable, but as we were not in a position to verify them without losing the opportunity of proceeding to Ste Marie, where we hoped to work under more favourable conditions, we decided to undertake the journey.

We landed at Ste Marie in the afternoon of 4th July, after having experienced the greatest difficulties in the transport of our breeding-cages, which, both in respect of their weight and volume, were exactly what they ought not to have been.

From the 5th to the 9th July we visited the south and south-eastern parts of the island, without any result ; while the natives we employed to search for *Oryctes* larvae and adult Scoliids were no more successful, although flowers capable of attracting the wasps were plentiful. The coconut palms, which very rarely exceeded 30 plants per village, did not show any signs of damage due to *Oryctes*. Decaying trunks were therefore extremely rare, and the only larvae of *O. simiar* obtained were found in a decaying stump of Bois Noir (*Albizzia lebbek*). So far as Scoliids were concerned, only *Elis thoracica* was observed in numbers on *Stachytarpheta indica*.

On the whole the result of our stay in Ste Marie—where, according to Coquerel, we ought to have found the insects we came for in abundance—proved unsatisfactory so far as the principal object was concerned ; on the other hand, it was not entirely devoid of interest, considering the deductions following from the data gathered.

That *S. oryctophaga*, as stated by Coquerel, was a serious enemy of *O. simiar* and *O. ranavalo* was shown by the relative scarcity of these two beetles. No doubt the disappearance of the coconut plantations, which through their state of neglect favoured the development of *Oryctes*, had greatly contributed to reduce their numbers ; on the other hand, there existed numerous habitats scattered along the west coast where these insects would certainly have been much more numerous had they not been controlled to an appreciable extent by their natural enemies. This was particularly striking on Mr. Leroy's plantation, where *Oryctes* larvae were relatively scarce in spite of the abundance of decaying coconut trunks.

We had, moreover, verified one of the hypotheses put forward at the beginning of this report to explain the sudden appearance of Scoliids in Tanamakoa, viz., that the Scoliids could be attracted from far by special plants for which they exhibited a marked partiality. *Elis thoracica*, for example, which we found in considerable numbers on "queue de rat" (*Stachytarpheta indica*) on the plain of Tanamakoa, was again found at Ste Marie visiting the same plant exclusively. Again, *S. oryctophaga*, which, it is true, occurred in very small numbers, was never found visiting any other plant except a certain shrub with red berries, the same being true for *S. iridicolor*.

There were on the plain contiguous to the coconut plantation, and on the plantation itself, various other flowers such as *Convolvulus*, *Lantana*, *Stachytarpheta*, a wild variety of periwinkle, and many others which we could not identify, of which the insects took no heed. The preference shown by these Scoliids for the shrub with red berries was so marked that it soon caught our attention, and subsequently we searched for them only on these plants, which, though covered with fruits, had still a few flowers. All our captures were effected on some 10 shrubs, and the plant

was observed in numbers only in two places. Judging from the number of Scoliids found on the few flowers still existing, there was reason to believe that when the plants were in full bloom these places would have been visited by a considerably greater number of Scoliids, which gradually dispersed as the flowers diminished. It will be seen that, in the end, this idea was not too wide of truth, and that the indication it afforded led ultimately to the success of this expedition.

During the 18 days that we spent at Ste Marie we captured 98 Scoliids, as follows : In Ambatora, on one occasion, 1 male *S. oryctophaga* and 6 *S. iridicolor* ; in Antsirakaraiky coconut plantation, 4 female and 5 male *S. oryctophaga*, 88 *S. iridicolor* and 1 *Campsomeris*.

After our return to Tamatave we again visited, between 25th and 31st July, the environs of the town, capturing only two female *S. oryctophaga*. On the 31st Mr. Gebert left Tamatave with the following female Scoliids, distributed in three separate cages : 10 *Scolia oryctophaga*, 63 *S. iridicolor*, 2 *Elis romandi*, 12 *E. pfeifferae*, and 40 *E. thoracica*.

As it became evident that there was not much chance of securing *S. oryctophaga* in numbers within the space extending from the town to the Jardin d'Essai, I transferred my headquarters to the latter point during the period required for exploring the tract which extends from there to Ambodiriannana, where a halting-place exists, and where, according to Mr. Mathiaux, the Chief Land Surveyor of the province of Tamatave, *Oryctes* and *Rhizoplatys bituberculatus* had been found in numbers in previous years.

From the Jardin d'Essai, which is situated on the banks of the Ivoloina, 12 km. from the town, the vegetation changes abruptly. The flat swampy plain, studded with stunted spiny shrubs and with semi-arborescent ferns, is replaced by low hills covered with ravenala and bamboo and a thick undergrowth. Between these knolls raphias and other plants thrive on the wet and swampy soil. On the greater part of the road, which winds in between these knolls, the bush is so thick as to be impenetrable. On the edge and sides of the slopes of the the road are scattered *Lantana*, *Convolvulus*, and *Stachytarpheta indica*, all in bloom. Around the Malagasy huts, grouped in villages, occurred banana plants and a little sweet potato or manioc. Along the Ivoloina coffee plantations occupy the largest area (Plate vi). At first sight the conditions seemed unfavourable for the attraction of Scoliids.

On the day following my arrival at the Jardin d'Essai on 1st August, I visited the country over a course of 18 km., up to Ambeletenina village, without any result ; on the following day I started again by the same route. At 11 a.m. the weather was so bad that after having covered only 6 km. our chair-bearers, being drenched to the skin, refused to go any further. From the point where I halted the hill slopes gently towards the river, being covered with an arborescent Malvaceous plant with pink flowers, *Urena lobata*, which the natives call paka or pampan. I inspected this spot in every direction without at first coming across a single insect.

As, however, this seemed the only place within a radius of 5 km. likely to attract Scoliids, and as numerous sunbirds (*Nectarinia souimanga*), which feed only on honey, were seen hovering over these plants, the ground seemed worthy of further investigation. By noon the weather had greatly improved, and suddenly Scoliids arose from everywhere. In an hour's time I had captured 20, including 11 female *S. oryctophaga*, 1 female *S. caffra*, 4 female *E. romandi*, 3 male *E. pfeifferae*, and 1 male of a new species. From this point up to Tamatave, whither I had to return in order to place my captures in breeding-cages, I could not find any other Scoliids, although, as already stated, the slopes of the road were covered with flowers other than pakas.

The next day, 4th August, I returned to the first paka field in very bad weather ; but it improved by one o'clock, and I captured 20 other Scoliids, including 9 female *S. oryctophaga* and 11 female *E. romandi*.

On the 5th I proceeded to Anamalotreta. This village occupies the end portion of a sort of peninsula formed by the junction of two rivers that isolate it on the east from the plains that extend in the direction of the sea. On the left of the road, where the peninsula widens, begins the region of hillocks ; 2 km. further west the Ivoloina directs its course eastwards towards the sea.

The native huts are here surrounded by citrus fruits and coconut palms ; behind them on the plain were a few sweet potato fields in full bloom. Paka plants were numerous, but scattered, and had almost entirely lost their leaves. A small field of sweet potatoes in full bloom was observed, over which large numbers of male *S. oryctophaga* were flying close to the ground, sometimes alighting on heaps of dried leaves and weeds, in the midst of which they disappeared, to emerge soon after. After two hours' waiting I captured five males, having failed to see a single female, and on retiring to the village several other small sweet potato fields were seen, in one of which I captured 10 females on the flowers in less than an hour.

Later I visited other fields without coming across any more Scoliids. On returning I noticed a great number of the wasps at the top of a mandarin orange tree, of which the flowers had hardly commenced opening out. To capture them I had to climb up to the top of the tree, and in two hours had caught 17 female *S. oryctophaga* and 3 males, bringing up to 48 the number of females captured in four days.

On 8th August I forwarded to Mauritius 140 Scoliids, including 97 female *S. oryctophaga*. From the 9th to the 19th, the date on which I left Madagascar for Mauritius, I captured on a few mandarin orange trees at Anamalotreta 767 Scoliids, including 434 female *S. oryctophaga*.

**A Method of concentrating the Parasites in a given Area.**

From 14th June to 2nd August (54 days) our total captures in Ste Marie and Tanamakoa, for a journey of more than 100 km., amounted only to 12 female *S. oryctophaga* and *E. romandi* ; while from 2nd to 19th August (17 days), and within a perimeter of 100 metres only, 15 female *S. oryctophaga*, 128 males, and 20 *E. romandi* (163 insects in all) were secured, a number which may be regarded as very satisfactory, considering the large size of the insects.

So great a difference in the number of insects captured in these two different periods can only be accounted for by appealing to particular conditions, for it would be unreasonable to suppose that all these insects were originally present in the place where they had been captured, inasmuch as the conditions favouring the development of *Oryctes* and other Lamellicorn beetles did not differ at all there from those that obtained elsewhere. If we examine the various hypotheses previously put forward we can see that the effect of season is insufficient to account for so great a gathering of insects at one particular spot. That these insects should be more numerous at a certain time of the year is but natural. If, however, this was the only controlling factor they would be distributed more or less uniformly, thus frequently bearing a constant ratio to the number of *Oryctes*. It has, however, already been pointed out that the dissemination and relative scarcity of *Oryctes* larvae precluded the possibility of securing the number of Scoliids needed in the cocoon stage.

The hypothesis that the gathering of these insects is attributable to their sedentary habits does not hold good in view of the facts mentioned above, and the third hypothesis remains, viz., that the insects possess an extraordinary capacity for flight, which enables them to seek the kind of food that they prefer over considerable distances. The facts observed at Ste Marie, in the paka field, and at Anamalotreta village support this view. The absence of Scoliids on flowers of Convolvulaceae at Ste Marie, as well as on the Ivondro and on the plains of Tamatave, and the presence of these insects in considerable numbers on these same flowers at Anamalotreta would appear to conflict with this view at first. But a closer examination shows that

the partiality exhibited by these insects for certain flowers, though not exclusive, is none the less real; and that this partiality is extended in various degrees to a certain number of flowers.

For example, the gathering observed on the paka field indicated that the flowers of this plant exerted on these insects a peculiar attraction that induced them to abandon other flowers in the region to group themselves at the point where these plants occurred. Their sudden appearance in numbers on two successive days, together with the subsequent absence of other Scoliids after the existing lot had been captured, tend to prove that the insects, whether they had reached this field directly or by stages from long distances, had established their quarters there for some time, owing to the existence of their favourite pasture. This case bears a complete analogy to that of Ste Marie, though in Ste Marie the scarcity of flowers on the shrub with red berries had already caused the dispersion of a good number of insects. This dispersion would have occurred subsequently in the paka field, as there was no other plant on which the Scoliids could feed.

At the time I visited Anamalotreta the scarcity of paka flowers had already made itself felt, and would probably have led to the dispersal of the wasps had not the sweet potatoes been in bloom, thereby retarding their exodus. The blossoms of mandarin orange trees further intervened, and thus extended the duration of the gathering until the time of our departure from Tamatave, on 19th August. The fact that these insects abandoned the sweet potato flowers on the very day on which the mandarin flowers opened brings out clearly their partiality for certain flowers, and explains at the same time why we hardly ever came across these large Scoliids on convolvulus and various other flowers. This peculiarity, to which we owe the success of our enterprise, has a far greater significance than one would assign to it at first sight.

In a country like Mauritius, where *Oryctes* are found everywhere, the important point is not a reduction of the total number of these insects, but a reduction induced at particular points, *i.e.*, on cultivated lands, where the intensity of the infestation is responsible for considerable damage. To attain this end it would suffice to group at particular spots where *Oryctes* are numerous and harmful the greatest possible number of Scoliids. This gathering could easily be induced by establishing at these points some description of artificial pastures which would confine the wasps thereto as long as required.

These observations are equally true for other species than *S. oryctophaga*; for example, *S. iridicolor*, *Elis pfeifferae*, and *E. thoracica*, the last-named species having a preference for "queue de rat" (*Stachytarpheta indica*). In Mauritius *Cordia interrupta* attracts *Tiphia parallela* in a somewhat similar fashion; while *Elis rufa* also feeds on its flowers.

It follows from the foregoing remarks that it is useless to endeavour to acclimatise Scoliids in a new environment unless their habits are known and the conditions favourable to their acclimatisation are fulfilled, such as the supplying of the proper flowers to serve as food for the adults. In countries such as Queensland, Porto Rico, etc., where white grubs are responsible for considerable damage and where their natural enemies already exist, advantage might be taken of the feeding habits of the adult parasites to increase the efficiency of their control by providing suitable pasturage on the lines indicated.

### Conditions under which the Scoliids were conveyed to Mauritius.

*Scolia oryctophaga* is an extremely hardy species and is easily reared in captivity. The cages used for conveying these insects from Madagascar to Mauritius were large Wardian cases in which *Tiphia parallela* had been imported from Barbados. On account of their size and weight these cases could not easily be carried about and had to be left behind whenever we went into the bush. In practice, the insects as

they were caught were transferred into small portable laboratory breeding-cages, the internal dimensions of which were 30 in. in height and 25 in. in length and breadth. The sides and tops were of wire gauze, while the bottom was covered with soil. When, as often happened, trees had to be climbed to capture Scoliids, the insects were placed for the time being in stoppered tubes kept in the pocket and transferred later to the laboratory cages. As we often remained away from our starting-place for more than two days, the insects had to remain during this time in the small cages, which at times contained over 50 Scoliids.

As can be gathered from this procedure and from the difficulties necessarily attending the transport of Wardian cases—*e.g.*, embarkation in a rough sea, transhipment, overcrowding, landing in Mauritius, and finally the transport of the cages 20 miles away from the landing-place for ultimate liberation—the insects were handled a great number of times and were often kept under conditions most unfavourable to their welfare, and it is surprising that the death-rate was not higher. Actually, of 1,033 insects shipped, 805 were landed alive in Mauritius.

Before transferring the insects to the Wardian cases these had been amply stocked with *Oryctes* larvae, which were allowed to bury themselves in a layer of soil and bits of decaying wood that had been placed in the bottom of the case. As food for the wasps honey was used. The honey container consisted of a block of wood in which several holes had been bored. These were filled with honey and the block placed in the soil contained in the cages every afternoon after the insects had dug themselves in.

It seems from experience that if it is desired to bring about reproduction *en route* the best plan would be to confine the insects in separate earthenware pots covered with a wire gauze cylinder and containing only an appropriate number of larvae.

## Laboratory Experiments.

Preliminary investigations in Madagascar showed that *Scolia oryctophaga* was capable of successfully parasitising *Oryctes tarandus* ; breeding experiments were conducted in the insectary at Reduit with these two insects after the return from Madagascar. The method of working adopted was to breed the insects in large earthenware pots 30 cm. in diameter and 25 cm. deep at the centre. These were filled with soil to a depth of 10 cm. from the top. Bits of cane were buried at various depths in the soil to serve as food for larvae of *Oryctes tarandus*, which were placed in the pot and allowed to dig themselves in. The pots were each covered with a wire gauze cylinder fitted with a lid on the top.

After the Scoliids had been inserted into the pots the contents were examined every five or six days. As soon as a larva had become parasitised it was removed to the laboratory and placed in an artificial cell in a large Petri dish covered with a bell-jar, on the sides of which black paper had been pasted to intercept the light. The cells were made by filling the Petri dish with moist earth up to the rim and then pressing down upon the soil with the thumb so as to form a cavity, in which the parasitised larva was laid. As soon as the larval parasite was full-grown and had removed its neck from the body of the grub, a cover was moulded out of clay soil and placed on the cell so as to close it completely and afford the Scoliid larva the necessary interior surface for fixing its silk when starting the cocoon. After the cocoons had been completed they were stored in a layer of soil 2 in. deep, which was always kept moist.

## The Life-cycle of *Scolia oryctophaga*.

*Egg.*—The egg is white, elliptical, slightly arched, and measures 4 mm. by 1 mm. ; it is laid in the middle of the ventral part of the third abdominal segment of the beetle larva (Plate vii, fig. 1).

The greatest number of eggs laid by females in captivity was 19, the egg-laying period extending over a month and a half; but probably more eggs are laid under natural conditions. At the beginning of the laying period an egg is deposited nearly every two days, and not infrequently every day. Towards the close, however, laying becomes very irregular, the intervals between the later layings being five to six days. The period of incubation is usually six days, very rarely five. The cell in which the parasitised larva lies, contrary to what is generally supposed, is not constructed by the larva itself, but by the Scoliid before the egg is deposited.

*Larva* (Plate vii, figs. 2, 3).—The young larva measures 5 mm. without the neck, which is inserted in the body of the *Oryctes* larva. Larval growth takes place slowly and regularly during the first two days. The average increase from the first to the seventh day is about 2 mm. a day, the average size of the larva on the seventh day being 14 mm. by 8 mm. From then onwards rapid and marked increase takes place, averaging 5 mm. a day; on the last day the larva remains attached to its host, the growth during the last six hours being 3 mm., at the end of which time the larva has reached the size of 28–30 mm. by 10–12 mm. without the neck, and 38–40 mm. in total length. These dimensions are for male larvae; the females attain 31–33 mm. by 15 mm. without the neck, and 40–45 mm. in total length. The duration of the larval period is 10 to 12 days.

*Pupa*.—The male cocoon is generally smaller than that of the female and varies in size from 28 by 11 mm. to 33 by 14 mm., while that of the female is less subject to variation and measures on the average 38 by 17 mm. Both are ovoid, yellowish-brown in colour, and consist of a case of hard resistant material about 0·3 mm. thick, covered with three layers of silk of thin texture (Plate vii, fig. 4). The duration of the pupal stage varies enormously, some individuals taking three months and others 10 to 14 months. The reasons that determine these variations are not clear, especially in view of the fact that in one case, viz., the progeny of a parthenogenetic female, the pupal period was the same for all the offspring, whilst in the case of another female (sexual) the pupal period of the progeny varied from 3 to 11½ months, although the conditions were exactly similar throughout. It is obvious, however, that there can be only one generation a year.

*Adult*.—As Coquerel has already described the insect at length, only a brief description is given here. The female (Plate vii, fig. 6), which is a very stout insect, measures 35 to 40 mm. in length and 10 mm. in width at the thorax and abdomen. The head, the fore legs, and the terminal joints of the antennae are of a reddish-brown colour, while the abdomen and hind legs are black with a brilliant lustre. The wings have a spread of 60 to 65 mm.; they are smoky in colour and slightly iridescent; on the margin of the front wing there is a broad rust-coloured band, which does not extend to the tip of the wing.

The male (Plate vii, fig. 5) is smaller and more slender, and is also more pubescent; its antennae are nearly twice as long as those of the female. Whilst the female shows a marked constancy in size, the male, on the contrary, exhibits great variations. The average male measures 35 mm. in length, but specimens measuring only 21 mm. have been met with.

*Parthenogenesis*.—Nowell, when dealing with *Tiphia parallela*, called attention to the phenomenon of parthenogenesis in Scoliids. The case of *Scolia oryctophaga*, recorded here, leads to the belief that it will prove to be a not unusual phenomenon in this group of Hymenoptera.

## Notes on other Scoliids in Madagascar and Mauritius.

*Scolia carnifex*, Coq.

Coquerel records having found this species in decaying coconut trunks containing *Oryctes* larvae, and concluded that, like *Scolia oryctophaga*, it parasitised *Oryctes*

*simiar* and *O. ranavalo*. It is remarkable that it was not found by us either at Ste Marie (where according to Coquerel it was plentiful) or at Tamatave.

*Campsomeris* (*Liacus*) *nigrita*, F.

Only two females of this species were captured, on the north coast of Ste Marie.

*Scolia caffra*, Sauss.

Three specimens of this species were caught in Tamatave, at Anamalotreta on mandarin orange trees.

*Scolia madecassa*, Sauss.

This species was not found by us either at Ste Marie or at Tamatave. Judging from the great number of specimens existing in the collections of the Museum of the Academia Malgache in Tananarive and labelled "Emyrne," it would seem that this species must be extremely common on the central plateau, where it probably parasitises some Lamellicorn beetle that lives in marshy soil.

*Scolia iridicolor*, Smith.

This is the commonest of the Scoliids found in Ste Marie, but it is relatively rare in Tamatave. It is not improbable that this species may prove to be the natural enemy of *Rhisoplatys bituberculatus* or of *Doryscelis calcarata*, since the larvae of these two Lamellicorn beetles were the only ones to be found in the locality where this wasp was observed in numbers.

*Elis romandi*, Sauss.

The female of this species is slightly larger than *Scolia oryctophaga* (35–40 mm.), whilst the male is much smaller, its size being only 25 mm. It is undoubtedly the parasite of one of the large species of *Oryctes*. It is very rare in Tamatave as compared with *Scolia oryctophaga*.

*Elis pfeifferae*, Sauss.

This species varies much in size. It is fairly common everywhere in Tamatave and feeds indifferently on any flower. It has been noticed on several occasions emerging from the soil where Melolonthid larvae (probably of the genus *Encya*) were present in numbers in cane stools.

*Elis thoracica*, F.

This species is extremely common in both Ste Marie and Tamatave. It feeds chiefly on "queue de rat" (*Stachytarpheta indica*). On the sandy plain of Tanamakoa, where it exists in numbers, the only larvae found were those of *Heteronychus*.

*Elis rufa*, Lep. (Plate viii).

This species, which is peculiar to the Mascareine group, has not hitherto been found in Madagascar. In Mauritius its distribution is partial, the wasp being practically unknown in certain localities and extremely common in others, *e.g.*, Pamplemousses.

It parasitises two indigenous Melolonthids that attack sugar-cane, which have been described recently by Mr. G. J. Arrow, of the British Museum, under the names of *Rhizotrogus pallens* and *R. gravidus* (Plate ix, figs. 4–6) respectively. These beetles would undoubtedly be serious pests of sugar-cane, were they not checked by this Scoliid.

In general the relationship existing between the host and the parasite are so well balanced that the mere presence of the parasite points to the existence of the host, although in most cases it is extremely difficult to find the latter.

The habits of this Scoliid present no peculiarities apart from the fact that it exhibits a marked partiality for certain plants, like *Scolia oryctophaga* and some other species. In Pamplemousses, where the flowers are varied, this wasp visits almost exclusively *Cordia interrupta* (Herbe Condé), whilst at Reduit, where this plant does not exist, it visits *Lantana* and *Convolvulus*, exhibiting a preference for the latter.

Though the females are on the wing in varying numbers at any time during the day, it is between 11 a.m. and 3 p.m. that they are met with most frequently. The males do not go underground, but they have a curious habit, common to many solitary Hymenoptera, of collecting in considerable numbers at night on the same twig, forming thereby compact swarms of several hundred insects.

This species varies in size. Plate viii, fig. 6, shows the limits of this variation in males and females respectively.

The life-cycle varies but little from that of *Scolia oryctophaga*, the chief difference being in the duration of the pupal stage, which has never been found to exceed three months, the development of the egg and larva lasting 5 and 12 days respectively.

This insect thrives fairly well in captivity and can be reared just like *S. oryctophaga* in pots, but requires a deeper layer of soil, 8 in. deep at least. The parasitised beetle larvae are found 4 in. to 6 in. underground, and are never enclosed in cells.

**The Results of the Introduction.**

It is difficult at the present time to give precise information concerning the results of this importation, in view of the conditions under which the liberation of the Scoliids was effected. Lack of a precise knowledge of the habits of these insects at the outset prevented preliminary preparation or the grouping together of conditions likely to induce the gathering of insects at particular spots where they had been liberated, thereby excluding the possibility of following closely the progress of their acclimatisation.

The absence of flowers at some of the spots where *Scolia oryctophaga* were liberated resulted in the rapid dispersion of these insects. On the day following their liberation only two or three insects were to be observed hovering over the place where they were originally set free, and three days afterwards not one was to be found. There is no reason to believe that they had all perished in so short a time, inasmuch as females coming from the same importation lived in captivity for several weeks after having parasitised larvae of *Oryctes tarandus*. In August 1918, *i.e.*, one year later, a female was found at Riche Bois and another at Reduit, and in September of the same year another female was found at Riche Bois.

Observations showed that this Scoliid in the free state had parasitised *Oryctes tarandus*. There is ground, therefore, for believing that the insect has acclimatised itself in Mauritius, although a considerable time must elapse before it can control to an appreciable extent the damage done by the *Oryctes*. So far as concerns the other species imported at the same time as *Scolia oryctophaga*, there is no indication as yet that they have established themselves in the island.

Now that sufficient data have been acquired as to methods and requirements, it is proposed to make further importations of these insects at a convenient time in the future.

Typical landscape in Tamatave Province, Madagascar, on the River Ivolcina.

## EXPLANATION OF PLATE VII.

*Scolia oryctophaga*, Coq.

Fig. 1. Egg on larva of *Oryctes tarandus*.
,, 2. Larva attached to larva of *O. tarandus*.
,, 3. Full-grown larva.
,, 4. Cocoon.
,, 5. Adult male.
,, 6. Adult female.


*Scolia oryctophaga*. Coq., and its early stages.

## EXPLANATION OF PLATE VIII.

*Elis rufa,* Lep.

Fig. 1. Egg attached to young larva of *Rhizotrogus pallens,* Arrow (slightly reduced).

,, 2. Larva three days old.

,, 3. Full-grown larva in cell, with empty skin of larva of *R. pallens.*

,, 4. Cocoon.

,, 5. Evacuated cocoons of female and male removed from their silky envelopes (below).

,, 6. Males and females, showing variation in size.


*Elis rufa*, Lep., and its early stages.

## EXPLANATION OF PLATE IX.

Fig. 1. *Oryctes tarandus*, Oliv., larva.
,, 2. ,, ,, ,, pupa in cell.
,, 3. ,, ,, ,, ♀ and ♂.
,, 4. *Rhizotrogus gravidus*, Arrow, larva (a parasitised specimen on left).
,, 5. ,, ,, ,, ,, side view.
,, 6. ,, ,, ,, ♂ and ♀.


***Oryctes tarandus***, Oliv., and *Rhizotrogus gravidus*, Arrow and early stages.

# MYCETOPHILID FLIES AS PESTS OF THE CUCUMBER PLANT IN GLASS-HOUSES.

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(Plate X.)

Severe injury to the roots of cucumber plants has occurred since January of this year (1922) through the attacks of the larvae of certain minute "fungus-gnats" belonging to the family Sciaridae. Although such attacks have not been recorded previously by growers of cucumbers, it is more than probable that the flies have been present in glass-houses for a number of years, and that damage arising through their agency has mistakenly been attributed to "eel-worms."

The first serious outbreak was recorded in January, a very large number of pot-plants having been damaged to the point of destruction in a nursery at Enfield Wash. The matter was taken up, and the causative factor proved beyond doubt to be larvae of *Pnyxia* (*Epidapus*) *scabiei*, Hopk. A description of *P. scabiei* has been given by Dr. A. D. Hopkins in the Proceedings of the Entomological Society of Washington, vol. iii, p. 152, in 1895, when the larvae of this fly were regarded as at any rate one of the causes of the disease known as "potato scab."

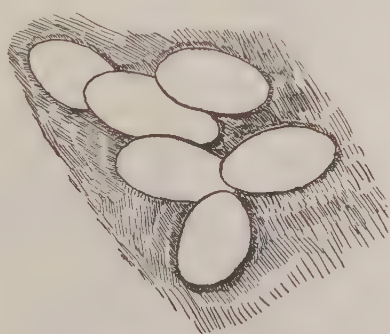

Fig. 1. *Pnyxia scabiei*, Hopk., eggs, × 60.

Fig. 2. Larva of *Pnyxia scabiei*, Hopk., × 33.

As the publication referred to is not readily available, a few of the more important points in the life-history are here taken from Dr. Hopkins's paper. The eggs (fig. 1) are laid by the female fly to the number of 20–30 in soil or manure, and take 5–6 days in hatching. The larvae (fig. 2), which are white with black heads, feed for a period

of 7–8 days. Finally they spin a cocoon of a dark silky substance, in which they turn to a white pupa (fig. 3), the adult fly emerging three days later. The female fly is wingless (fig. 4), and the males are of two kinds, one with long and the other with short wings (figs. 5, 6). The female deposits the eggs 5–6 days after emergence. Broods of flies appear every 20–25 days.

Fig. 3. Pupa of *Pnyxia scabiei*, Hopk., × 33.

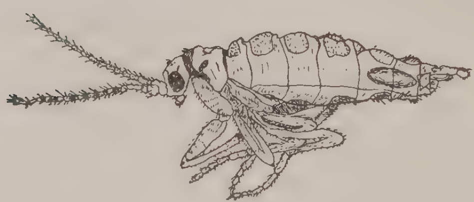

Fig. 4. *Pnyxia scabiei*, Hopk., ♀, × 33.

Fig. 5. *Pnyxia scabiei*, Hopk., ♂, long-winged form, × 33.

Details relating to the attack of *Pnyxia scabiei* on cucumbers at Enfield Wash are now given.

The cucumber plants were potted out from the seed-boxes (in which there had been no attack) in the middle of December 1921; the pot-soil was unsterilised and mixed with horse manure. Attack by the grubs was first noted on 8th January 1922, and between then and 12th January some 600 plants were destroyed. The tap-root of the infected plants had been eaten into by the larvae, and hollowed out from below upwards to within quarter-inch to half-inch below the soil surface. Some root stems contained as many as 60 larvae. On no part of the plant were any eggs found. When full-fed the larvae ate their way out of the stem below the ground and pupated in

the soil. At this time the soil of the pots was teeming with minute winged flies, which proved to be males of both long-winged and short-winged types.

Fig. 6. *Pnyxia scabiei*, Hopk., ♂, short-winged form, × 33.

On 20th January several females made their appearance in the soil of the pots, one being found at a depth of quite 1 in. below the soil surface. Three males and three females were caught *in copula* and placed in separate glass tubes, one containing moist soil, one horse manure, and the third a piece of cucumber stem without soil.

Fig. 7. *Plastosciara perniciosa*, Edwards, ♀, × 33.

All three females had deposited some eggs by 23rd January, but those laid in the third tube had been deposited on the glass, and not on the cucumber stem, and both male and female were dead. In the other two tubes the females lived till the day following, and had then deposited 28 and 25 eggs respectively, a few millimetres below the soil surface. The eggs are oval, white and shining, and measure 0·28 mm. in length.

**Conditions conducive to Attack.**

It is now practically certain that the larvae (doubtfully the eggs) are brought into the houses with manure at the time of planting. In more than one nursery in the

Lea Valley great numbers of flies have been observed shortly after the introduction of the borders into the houses, yet here no damage has resulted to the cucumber plants.

The attack described above followed on a period when the pot-plants had admittedly been watered insufficiently, and there is no doubt that the larvae are dependent upon a certain moisture content in the soil, a deficiency of which causes them to invade the roots of the plant. In making recommendations for control, it will be seen that an excess of moisture in the soil is fatal to the life of the larvae, but before describing some experiments in this connection mention will be made of another Sciarid fly which has appeared as a severe pest, namely, *Plastosciara perniciosa*,

Fig. 8. *Plastosciara perniciosa*, Edwards, ♀, pupa, × 60.

Edwards (Entomologists' Monthly Magazine, July 1922, p. 160). This minute black fly (fig. 7) is very similar to *Pnyxia scabiei*, but both sexes of the fly have wings. Recently there has been a very serious outbreak in cucumber houses in the Worthing district, and another attack has been reported from Dartford. The attack has been confined to fruiting plants in the border, the hundreds of larvae having reduced the tap-root to a pulp, and caused much further damage by removing the cortex of the stem just below, and sometimes even above, the soil surface (Pl. x, figs. 1, 2). The adult flies swarm in the morning, in bright sunlight, and are found in company with *Pnyxia scabiei*.

## Control Measures.

With a view to killing the larvae in the soil, the following chemicals have been used :—

Potassium sulphide, 2 per cent., 1 per cent., and 0·5 per cent. solution ; 100 cc. to the pot, 2 applications.

Ammonium carbonate and copper sulphate, 2 per cent., 1 per cent., and 0·5 per cent. solutions ; 100 cc. to the pot, 2 applications.

Mustard, 2 per cent., 1 per cent., and 0·5 per cent. solutions ; 100 cc. to the pot, 2 applications.

| | |
|---|---|
| Calcium chloride .. .. .. | 5 per cent. solution on larvae. |
| Ammonium carbonate .. .. | ,, ,, ,, ,, and on soil. |
| Nitric acid .. .. .. .. | 1 per cent. solution on larvae. |
| Hydrochloric acid .. .. .. | ,, ,, ,, ,, |
| Potassium bichromate .. .. | ,, ,, ,, ,, |
| Potassium permanganate .. .. | ,, ,, ,, ,, |
| Ammonia .. .. .. .. | ,, ,, ,, ,, |

Except for hydrochloric acid, which is dangerous to use on plants, none of these substances gave any appreciable result. During the experiments, however, some larvae were immersed in water, and it was found that they died in about an hour's time.

Accordingly, three infested pot-plants were placed in a pail, and water was added so that the surface of the soil was just covered. A number of adult flies floated to the surface and were unable to rise from the water. After immersion for 12 hours the plants and soil were examined, and no living larvae could be found. A number of larvae had left the pots and were dead at the bottom of the pail. Fresh plants were then planted in the soil of these pots, but no further attack resulted. In consequence immersion of the pots was at once carried out on a large scale, with entirely satisfactory results.

The larvae of *Plastosciara perniciosa* are as susceptible to moisture conditions as those of *Pnyxia scabiei*. Cucumber roots containing many thousands of larvae were placed in large pots with soil from the cucumber border in which the plants had been growing. Some pots were watered so that the soil was of the consistency of a pudding, while others were kept well on the dry side. After three days the soil was examined; the larvae in the wet pots had left the roots and about 98 per cent. of them had perished, while in the dry pots no dead larvae could be found. At the same time, in both cases where the attack had broken out favourable reports were received from the growers, and an improved condition resulted in the health of attacked plants after heavy watering had been carried out.

Fig. 1. Cucumber root showing larvae of Plastosciara perniciosa, Edw., and damage to the root-stem.

Fig. 2. The same root cleaned of earth, showing destruction of the tap-root.

# NEW INJURIOUS PHYTOPHAGA FROM INDIA AND BRAZIL.

By G. E. BRYANT,
*Entomological Assistant, Imperial Bureau of Entomology.*

## Family EUMOLPIDAE.

**Bromiodes squamosus,** sp. n. (fig. 1).

Elongate, subcylindrical, black, clothed with yellowish-brown and whitish scales with antennae and legs fulvous, the legs with whitish scales.

*Length*, 2·5–3 mm.

*Head* rather deeply inserted in the thorax, barely visible from above, covered with scales and impressed between the eyes. *Antennae* fulvous, reaching a little beyond the base of the prothorax, the first two joints wider and stouter than the four following,

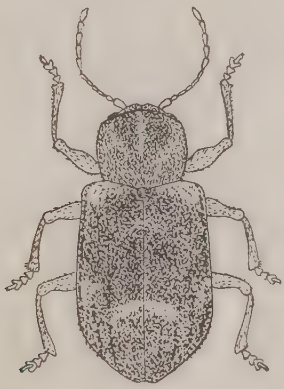

Fig. 1. *Bromiodes squamosus*, Bryant, sp. n.

and the five apical joints thickened and subtriangular, with the apical joint acuminate. *Prothorax* broader than long, subcylindrical, evenly punctured and covered with scales, with a central white line and white scales predominating at the sides, the base narrower than the elytra. *Scutellum* subquadrate, with brown scales. *Elytra* nearly twice as long as broad, narrowed to apex, covered with a groundwork of greyish scales, with scattered darker scales forming rather irregular striae ; the surface, if scales are removed, shining black, strongly and regularly punctured ; humeral angles strongly marked and somewhat oblique, with a whitish-grey patch near humeral angle, and a narrow white patch of scales behind middle on each elytron extending a short way from the suture, forming an ill-defined band. *Legs* fulvous, covered with scattered white scales. *Underside* black, strongly punctured, covered with whitish-grey scales, with the ventral segments about equal to each other, but the first rather longer than the second.

INDIA : Simla, 12.iv.1921, eight specimens (*O. H. Walters*).

Specimens were forwarded by Mr. Walters, with the information that they were attacking young leaves of pear trees in an orchard.

Allied to *B. indicus*, Jac., but differs in the scales being rather coarser and the lighter scales predominating. The head is also flatter and not so convex as in *B. indicus*, the prothorax shorter and not so much rounded at sides, and the elytra more parallel-sided.

**Brevicolaspis villosa,** sp. n. (fig. 2).

Oblong-ovate, subcylindrical, ferruginous, covered with rather dense yellowish-white adpressed hair-like scales, finer and longer on the prothorax than on the elytra.

*Length,* 4·5 mm.

*Head* vertical, flattened, covered with yellowish-white hairs, and at the base a short longitudinal impression; eyes reniform. *Antennae* filiform, ferruginous, with slight pubescence; the 1st joint long, 2nd very short, the 3rd and 7th about equal to each other, each rather swollen at apex, the last four joints shorter and darker and about equal to each other, reaching almost to the middle of the elytra.

Fig. 2. *Brevicolaspis villosa,* Bryant, sp. n.

*Prothorax* finely and evenly punctured, covered with long yellowish-white adpressed hairs. *Scutellum* subquadrate, with hair-like scales. *Elytra* about twice as long as broad, a little wider than the prothorax, and from about middle rounded to apex, strongly punctured, ferruginous, covered with yellowish hair-like scales, which are shorter and coarser than those on the prothorax. *Legs* ferruginous; femora with hair-like scales and all armed on the underside with a small tooth, in both sexes; anterior tibiae armed with a small tooth on the outer side near apex. *Underside* ferruginous, with hairs more scattered and finer; ventral segments with the first about equal to the three following, with only fine short scattered pubescence.

♂ differs from the ♀ in having the antennae stouter and longer.

South Brazil: Bahia, 10 specimens (*G. Bondar*), 1 specimen (*C. Darwin*), 1 specimen (*Read*).

Reported by Mr. Bondar as attacking coconut palms.

Differs from *B. pilosa*, Lap., in colour, in the antennae of the ♂ being shorter, the elytra more closely punctured, in the thicker and coarser hair-like scales, the colour of the scales being yellowish-white, not grey, and in the anterior tibiae being armed.

**Metachroma rosae,** sp. n. (fig. 3).

Fulvous ; prothorax very finely punctured, shining black, with the anterior margin and central portion of basal margin fulvous ; scutellum black ; elytra punctate-striate, with black markings forming a subhumeral black patch and an interrupted irregular transverse black band behind middle.

*Length*, 4–5 mm.

*Head* with a black longitudinal line between eyes to base, and the occiput black, rather strongly punctured on the vertex, the clypeus irregularly punctured. *Antennae* slender, reaching to about the middle of the elytra, all the joints fulvous. *Prothorax* broader than the head, nearly twice as broad as long, finely punctured, with the sides strongly rounded and the anterior angle slightly dentiform, sides behind middle

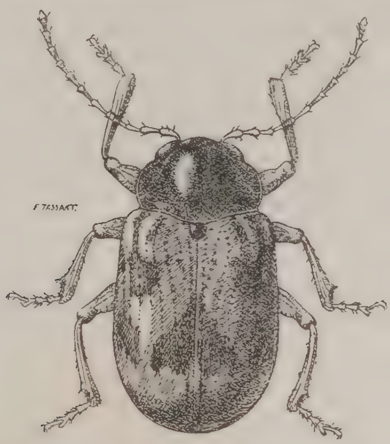

Fig. 3. *Metachroma rosae*, Bryant, sp. n.

slightly constricted to base ; shining black, with the anterior margin and central portion of basal margin fulvous (in some the black entirely reaches the base). *Scutellum* subquadrate, shining black. *Elytra* slightly broader than the prothorax, two and a half times as long as the prothorax, subparallel-sided, broadest behind middle and rounded to apex, punctate-striate, less strongly punctured towards apex ; a subhumeral irregular black patch extending from the fourth stria to a little beyond the eighth, not reaching the lateral margin, connected with the base along the basal part of the sixth stria and extending to about half the length of the elytron ; the interval at the base between the fourth and fifth striae is black, not extending to the black patch, and there is an irregular transverse black band behind middle interrupted at the fourth interval, the central portion forming a triangular black patch at the suture. *Underside* and *legs* fulvous ; all the femora with a very small tooth on lower margin ; middle and posterior tibiae emarginate on outer side near apex. ♂ smaller and narrower than the ♀.

JAMAICA : Manchester, 25.v.1917 (*A. H. Ritchie*).

Specimens forwarded by Mr. Ritchie, with the information that they were attacking the leaves of roses.

Allied to *M. quadrimaculata*, Jac., from Mexico.

### Family HALTICIDAE.

### Genus **Zomba,** nov.

Elongate, subparallel-sided, depressed. *Head* slightly transverse, depressed, not constricted behind, slightly narrower than prothorax ; labrum transverse, rounded ;

maxillary palpi filiform, with the 3rd joint cylindrical and longer than the 2nd, the 4th about equal to the 3rd and acuminate; eyes large, subglobose, flattened, not prominent and placed more on vertex of head than at the side; inner margin behind the insertion of the antennae slightly flattened. *Antennae* approximated, long and filiform; 1st joint longer than the 2nd, elongate and incurved to apex; 2nd narrower, ovate; 3rd–7th about equal to each other, each longer than the 2nd; apical four shorter and about equal, with last joint acuminate. *Prothorax* transverse, with a slight transverse impression at the base not extending to the sides, wider than the head; anterior margin convex, with the angles obtuse, and a small fovea situated in the angle; sides marginate and from the middle constricted to the base. *Scutellum* triangular. *Elytra* elongate, subparallel-sided, rounded behind middle to apex, broader than the base of the prothorax, about twice as long as broad, with a slight depression between the base and middle, strongly punctate-striate. *Legs* with all the femora stout, the hind pair much more so, with the lower margin straight; all the tibiae slightly broadening to the apex, the hind pair with the tarsal cavity at apex ciliate, terminated by a single spur; front and middle tarsi a little shorter than the hind pair, the latter with the 4th joint very much inflated; all the claws appendiculate. *Prosternum* with the coxal cavities practically closed, but they are in reality very slightly open; metasternum with a longitudinal impression in middle near posterior margin; the venter with segment 1 large; 2, 3, 4 about equal, each shorter than 1.

Allied to the South American genus *Glenidion*, Clark.

**Zomba gossypii,** sp. n. (fig. 4).

Elongate, subparallel-sided, depressed, rounded at apex. Entirely metallic blue-black, except basal joints of antennae and tibiae, which are testaceous.

*Length,* 2·75 mm.

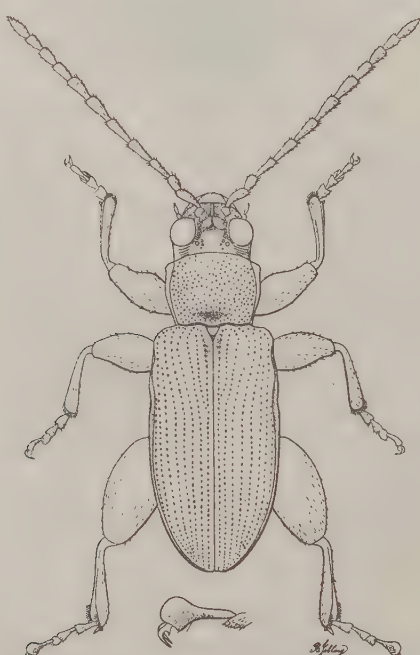

Fig. 4. *Zomba gossypii*, Bryant, gen. et sp. n.

*Head* slightly transverse, with a few scattered punctures near eyes; the eyes subglobose and flattened, not at all prominent, and the head not contracted behind them; transversely impressed between the eyes, and a longitudinal carina between the insertions of the antennae. *Antennae* approximate and filiform, slightly longer in ♂ than in ♀; the first four joints and the basal half of the 5th testaceous, the apical joints dark; 1st joint longer than 2nd, elongate and incurved to apex; 2nd ovate; 3rd–7th about equal to each other, but each longer than the 2nd; apical joints shorter and about equal to each other, with the last joint acuminate. *Prothorax* transverse, strongly punctured, and a little broader than the head; sides marginate, constricted from the middle to the base, anterior angles obtuse; a slight transverse impression in the middle near base not extending to the sides. *Scutellum* triangular, impunctate. *Elytra* at the base a little broader than prothorax, elongate, subparallel-sided, rounded at apex, strongly punctate-striate, shoulders well marked, and slightly depressed from about middle to base. *Legs* with hind femora incrassate; all the tibiae testaceous and broadening to apex, hind tibiae with spur at apex; the posterior tarsi with the 4th joint much inflated and the claws appendiculate. *Venter* with segment 1 large; 2, 3, 4 about equal to each other, and a little longer together than 1; 5 in the ♂ slightly notched, and all the segments slightly narrower than in the ♀.

NYASALAND: Luchenza, on cotton, iv.1916 (*C. Mason*). N.W. RHODESIA: Livingstone, Zambesi River, 29.i.1913 (*H. C. Dollman*).

This is the first species of the subfamily MONOPLATINAE to be recorded from Africa, the others being almost exclusively South American, but Blackburn in 1896 described an Australian genus, *Opisthopygme*.

# ON THE OCCURRENCE OF LEAF-EATING SAWFLIES ON CEREALS IN BRITAIN.

By A. Roebuck,

*Lecturer in Agricultural Biology and Adviser in Agricultural Entomology, Harper Adams Agricultural College.*

Each season since 1918 numbers of leaf-feeding sawfly larvae have been taken during the months of June and July in both oat and wheat crops. The larvae feed along the edges of the blades during the day and usually cut off the upper portion (fig. 1).


Fig. 1. Wheat leaves damaged by larvae of *Dolerus* and *Pachynematus.*

Attempts to breed the adults from these succeeded in 1920 and 1921, two species having been found to be responsible for the damage, *Pachynematus clitellus*, Lep., and *Dolerus haematodis*, Klug, which were very kindly identified by the Rev. F. D. Morice. The larvae disappear from the fields during the latter half of July and pupate in the ground. Emergence of the sawflies takes place in the laboratory during the first half of May. From measurements of larvae indoors and in the field this closely corresponds with the time of emergence out of doors.

Species of both *Dolerus* and *Pachynematus* have been recorded in America as attacking cereals (1, 2).

Emergence of the adults began on 4th May and finished on 14th May, the pupae being in pots of soil undisturbed from the previous July but occasionally watered. All the specimens died within 24 hours of emergence except a female *Dolerus*, and this oviposited on a young wheat plant. As the imagines were removed to separate chambers after emergence and no two were ever allowed together, the eggs were produced parthenogenetically.

This female exhibited no great interest in life during the first few days, but squatted about on the young leaf and moved its position a few times a day. On the ninth day (23rd May), from 3 to 5 p.m. on a bright afternoon, the insect exhibited signs of excitement, running along the edges of the leaves with the antennae violently quivering. After inspecting a number of leaves she began the work of oviposition. She took up a position facing the stem of the plant, and after feeling for the edge of the leaf inserted the " saws " and made about a dozen quick movements of the abdomen. Then followed a short pause, presumably to deposit the egg, after which the point of the abdomen was lifted from the surface of the leaf. The whole operation took about half a minute, and after a few minutes pause she moved further along the leaf and repeated the process. The following day this female died. There was nothing to indicate the presence of eggs on the leaves, and at first it seemed doubtful whether any could have been laid. During the next few days the eggs began to enlarge, and the swellings along the margin of the leaves showed exactly the purpose of the sawing and the number of eggs laid (fig. 2). In all, 64 eggs were deposited by this insect. The

Fig. 2. Wheat leaf with swellings containing eggs of *Dolerus*.

leaf was cut along the margin for about 1 mm., severing the upper and lower epidermises. Both sides of the leaves were used, and the spacing was quite irregular. Fifteen was the highest number of eggs on any one leaf, and only a single egg occurred on several leaves.

The young larvae hatched on the third and fourth days (26th and 27th May) the eggs by then being 1·5 mm. long, the cavity 2 mm., and the height of the swelling 1 mm. In all cases the head end of the larva was down the leaf or towards the stem (fig. 3).

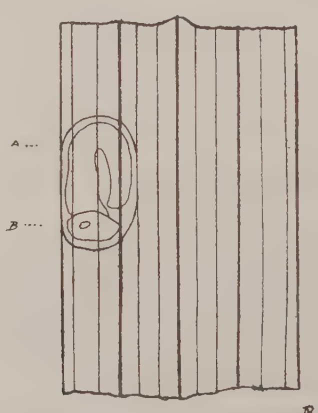

Fig. 3. Leaf rendered transparent to show position of egg and the larva within it ; the margin of the leaf is cut from A to B by the ♀.

It has so far been impossible to observe the oviposition in *Pachynematus* owing to the rapid death in captivity of the insects.

The young larvae were 2·5 mm. long and resembled the adults in coloration, being dark brown or nearly black along the back, with the lower part of the sides and the underside very pale, dull cream ; the vertex and eyes are black, the rest of the head pale. Full-grown larvae measure 17 mm. to 19 mm.

In addition to wheat and oats the larvae have been found on *Arrhenatherum avenaceum* (3), and Cameron, who figures and briefly describes the larva, states that it feeds on *Juncus effusus* and other species of *Juncus* and on *Scirpus lacustris* (4).

No larvae of *Pachynematus* under 8 mm. have been observed, when the coloration corresponds with the adult of 16–18 mm. Just before pupating there is a slight colour change to a uniform green. In addition to wheat and oats, *Poa trivialis* (3), *P. annua*, *Carex acuta* and other species of *Carex* and grasses are eaten (4). Cameron gives a full description of the larva, with a figure, and states that it is dimorphic. The larvae of both species lie almost motionless along the leaf-blades, although *Pachynematus* when alarmed is sometimes quite active.

Mature *Dolerus* larvae make no cocoon in the soil for pupation, but *Pachynematus* spins a thin brown cocoon. Cameron obtained cocoons in confinement on the leaves of the food-plants, but the writer was unable to do so ; the larvae simply remained inert during the winter and died in the early spring. The adults of both *Dolerus* and *Pachynematus* are common and apparently generally distributed. Both are fully described by Cameron, the latter under the name *Nematus capreae*. The amount of damage done by these species is slight, but they have regularly appeared during five seasons in different fields in the Newport district.

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3. MILES, " Relation of Grass Insects to Cultivated Crops," Annals of Applied Biology, vol. viii, nos. 3, 4.
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# A FROGHOPPER DAMAGING CACAO IN PANAMA.

By C. B. Williams, M.A., F.E.S.

(Plate XI.)

In the course of a search for parasites of Cercopidae in Central America, made on behalf of the Government of Trinidad in 1916 and 1917, I came across a froghopper of the genus *Clastoptera* destroying the flowers of cacao in various localities in Panama and just over the border in Costa Rica.

In view of its possible importance in a country where cacao planting is being taken up to an increasing extent, and of the danger of its spreading into other cacao-growing countries, some notes were made on it which are given below.

Apart from its economic importance, it was of considerable interest also from the fact that in the froth surrounding the nymphs I found a number of larvae of a Drosophilid fly. At the time I came to the conclusion that this was an inquiline and not injurious to the nymphs, so that little further attention was paid to it ; but observations made later on *Drosophila paradoxa*, Lamb, which is found in the froth of *Clastoptera taeniata*, Schmidt, in Trinidad, and which undoubtedly kills some of the nymphs, have made me regret that I dismissed the possibility so lightly.

Fig. 1. *Clastoptera theobromae*, Williams, sp. n.

The froghopper is very conspicuous from the masses of semi-liquid froth that it makes on the flower-stalks of the cacao (Plate xi). Each of these froth-masses contains from one to four or five nymphs, which suck the flower-stalk and cause its death. On one or two occasions I found the froth on the stalk of a small pod or at the base of young shoots growing from the main branches, but none was ever seen on the leaf-petioles or near the growing-point at the tips of the branches. The great majority of nymphs were on the flower-stalks, and these flowers invariably withered up and died.

The cacao tree is remarkable in that it usually produces a large excess of flowers, most of which are shed, so that the loss of even 50 per cent. of the flowers might have

no effect on the yield. On the other hand we have no evidence that the flowers killed by the froghopper are the ones that would have been shed naturally, or that they are replaced by healthy ones, and on some of the infested trees at least half of the existing flowers were destroyed.

The adult froghopper (fig. 1) is about one-sixth of an inch in length and very dark brown in colour. It has been identified for me as probably *Clastoptera scutellata* var. *funesta*, Stål, but I am doubtful of this determination. In view of the facts that (1) *scutellata* was originally described from Brazil, (2) my experience shows that the Central American species of CERCOPIDAE usually have a very limited range, (3) *funesta* as figured by Fowler (Biol. Cent. Am. Homopt., ii, pl. xii, fig. 14) has the scutellum yellow, (4) a critical study of the genitalia has never been made in this group, (5) more harm is done by a mis-identification than by one additional description, particularly by the confusion of the question of the distribution of a species of economic importance, I am describing it below as a new species, *Clastoptera theobromae*, and giving, in addition, accurate drawings of the genitalia, from which it should be recognised if found elsewhere.

**Clastoptera theobromae,** sp. n.

Total length about 4 mm., length of wing about 3 mm., width between eyes 1·16 mm., width across pronotum 2·3 mm., length of pronotum and scutellum 2·4 mm.

Head brown, eyes darker; pronotum and scutellum dark shining brown, occasionally lighter in the middle; wings dark shining brown, more transparent towards the tip; abdomen dark brown, legs lighter.

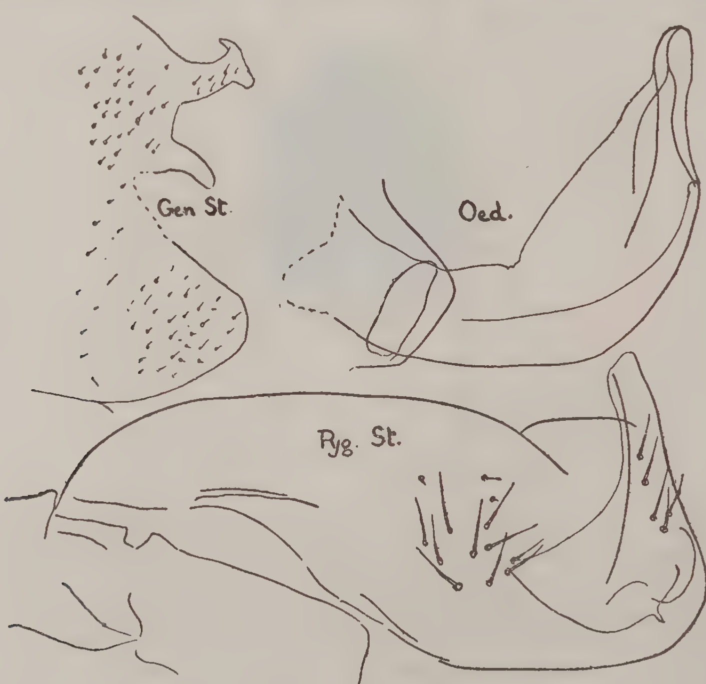


Fig. 2. Male genitalia of *Clastoptera theobromae*: Gen. St., genital style; Pyg. St., pygophoral style; Oed., aedoeagus.

Front smoothly rounded between the eyes, meeting the vertex in the same plane but with a distinct ridge between ; vertex slightly depressed. Pronotum finely and indistinctly striated transversely, about sixteen striations across the middle line, these being more distinct posteriorly. Fore wings finely rugose and finely pubescent, the hairs scarcely visible except in microscope mounts ; the veins on the clavus distinct ; a dark stigma filling the first apical cell and extending a little basally from this and preceded by a narrow longitudinal pale area which lies just away from the anterior margin of the wing ; the third apical cell not triangular (as in *C. delicata*, Ball) ; the first discoidal cell much smaller than the second. Spines on the hind tibiae very stout. Genitalia as in fig. 2.

*Habits.*—The eggs were not found, but all evidence points to their being laid in the tissue of the flower-stalk.

The nymphs are pale whitish-brown and are found usually one to three, but occasionally more, together in the froth masses on the flower-stalks of cacao. The froth of this species, although very watery, is strongly calcareous, and often dries externally to a chalky mass, which may persist on the tree for a long time after the adults have emerged.

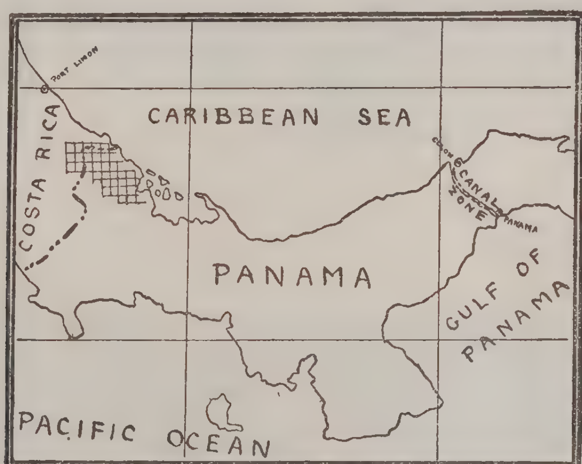


Fig. 3. Sketch map showing distribution of the Cacao Froghopper in Costa Rica and Panama.

The adults were extremely difficult to find in the field, and beating and sweeping trees heavily infested with nymphs only produced two adults. Many were, however, obtained by breeding.

*Parasites.*—The froth frequently contained one or two white elongate larvae of a species of *Drosophila*, and the brown seed-like puparia of this fly were also found. The question as to whether these were parasites or inquilines has already been discussed.

From a number of froth-masses put into a parasite box several small parasitic Hymenoptera emerged, but a later search revealed one of the same species inside a *Drosophila* pupa, so they were parasites of these and not of the *Clastoptera*.

*Food-plants.*—The insect was, with one exception, only found on the cultivated cacao, *Theobroma cacao*. The one exception was the finding of the doubtful remains of froth-masses on the flower-stalks of a wild tree in the forest, which bore deeply ridged cacao-like pods on the trunk and was obviously closely related to the cacao.

This is a very strong indication that the insect is native to the district and has gone to the cultivated cacao from the related wild species.

*Distribution* (fig. 3).—The insect was found in the following localities, which are all on or near the Atlantic coast on the border of the Panama Republic and Costa Rica, in the area shaded on the map :—

Panama Republic : Province of Bocas del Toro :—Chiquito, near Guabito, 20.vi.1917 ; Changuinola, ii.–v.1917 ; near Almirante, 7.vi.1917. Costa Rica : Talamanca Province :—Suretka, 4.iii.1917.

In addition to the above, Mr. J. B. Rorer, then Mycologist to the Department of Agriculture of Trinidad, reported to me that he had seen similar froth-masses on the flower-stalks of cultivated cacao at Machala, Province of El Oro (Pacific Coast), Ecuador, in December 1918, but no specimens were obtained for examination.

In Panama the insect was only seriously abundant on a few acres near Changuinola, and its present status is that of a potential pest which should be carefully watched in case conditions should become suitable for its rapid multiplication and spread.

Froth-masses of Clastoptera theobromae, Williams, sp. n., on flower-stalks of Cacao.

# NEW AND LITTLE-KNOWN MESOPOTAMIAN BLOOD-SUCKING DIPTERA (FAMILIES SIMULIIDAE AND TABANIDAE).

By Major E. E. AUSTEN, D.S.O.

With the exception of a short paper published some two and a half years ago by Major Patton, which, however, deals only with TABANIDAE,* little or nothing has hitherto appeared in print on the subject of Mesopotamian representatives of the two families mentioned in the title of the present contribution. It is therefore hoped that the following notes, however incomplete, may be of some slight assistance to collectors of blood-sucking flies who may be stationed in Mesopotamia, and may at the same time stimulate them to further efforts.

The bulk of the material described or mentioned in the following pages was collected either by Major A. D. Fraser, D.S.O., M.C., R.A.M.C. ; Major J. E. M. Boyd, M.C., R.A.M.C. ; or Mr. P. A. Buxton ; but all specimens available to the writer for examination have been noticed.

The whole of the material in question, including types of new species, is in the British Museum (Natural History).

## Family SIMULIIDAE.

### Genus **Simulium,** Latreille.

**Simulium bipunctatum,** sp. n. (fig. 1).

♀.—Length (11 specimens), 1·75 to just under 2 mm.

*Ground colour of head and thorax olive-grey† or deep olive-grey ; head, dorsum of thorax and entire surface of abdomen clothed with closely set, appressed, shining, silvery or yellowish-silvery hairs, making a light background with which a pair of deep black bare spots (shallow circular depressions) on dorsum of thorax close to its anterior margin forms a sharp contrast ; legs cinnamon-buff or ochraceous-buff, front tarsi (except extreme base of first segment) and tips of hind tibiae blackish brown, tips of middle and hind tarsi and also those of front and middle tibiae, at least on extensor surfaces, dark brown or brownish, hind femora incompletely banded with brown shortly before their distal extremities.*

*Head : front* in ♀ rather broad (measured on margin of vertex about as broad as long), but narrowing rapidly from above downwards ; *palpi*, blackish brown, sparsely clothed with pale hairs ; *antennae*, dark brown, second and two following segments ochraceous-tawny, dark brown portion clothed with microscopic, appressed, yellowish hairs. *Thorax* : dorsum when denuded or partially denuded exhibiting an incomplete, impressed, lyrate mark, similar to that seen on thorax of *S. equinum*, L., ♀, and consisting of a narrow, median, longitudinal straight line, and a curved arm, somewhat broader posteriorly and not in contact with median line either behind or in front, on each side ; median line of lyrate mark, when completely developed, extending from anterior margin of thorax to pre-scutellar depression ; lateral arms, which are sometimes brownish olive posteriorly, terminating abruptly behind, a little in front of level of costal border of wings, and anteriorly each ending in inner margin of corresponding black spots ; *scutellum* fringed posteriorly and laterally with relatively

* *Cf.* Patton, "Some Notes on the Arthropods of Medical and Veterinary Importance in Mesopotamia, and on their Relation to Disease.—Part I. The Gad Flies of Mesopotamia": Ind. Journ. Med. Res., Calcutta, vii, no. 4, pp. 735–750, pl. lxvii, text-figs. 1 and 2, April 1920.

† For names and illustrations of colours used for descriptive purposes in the present paper, see Ridgway, "Color Standards and Color Nomenclature" (Washington, D.C. Published by the Author, 1912).

long and fine, erect, whitish hair. *Abdomen*: fringe of hair on first tergite (abdominal scale) whitish or silvery, fairly long at sides; ground-colour of abdomen (normally completely concealed by the hairy covering) similar to that of legs, second and at least two following tergites each with a large, blackish, median blotch. *Wings* normal. *Halteres* ivory-yellow or cream-buff. *Legs*: first segment of front tarsi not expanded, in length about equal to the three following segments taken together; first segment of hind tarsi not expanded, last four segments of hind tarsi together equal to about three-fifths of first segment in length, second segment only about one-fourth longer than third, but without any noticeable dorsal excision; all claws long and slender, in each case with a large tooth, about half the length of the claw, at the base; hairy covering of legs similar in coloration and character to that of body.


Fig. 1. Head and thorax of *Simulium bipunctatum*, Austen, ♀ (hairy covering omitted).

*N.B.*—Basal segment of antennae should be shaded.

Mesopotamia, precise locality unknown; additional specimens from Daurah, R. Tigris. Holotype and six paratypes, precise locality unknown, 1921 (*Major A. D. Fraser*); four other paratypes, Daurah (five miles below Baghdad), May–June, 1920, "fairly common soon after sunrise" (*Major A. D. Fraser*).

Although in size and general appearance the species just described is not unlike the Nilotic *S. griseicollis*, Becker, of Upper Egypt and the Egyptian Sudan, the remarkable thoracic spots (fig. 1) at once distinguish *Simulium bipunctatum*, at least in the female sex, not only from the species mentioned, but also, so far as the writer is aware, from any of its congeners at present known.*

* What would appear to be a variety or local race of *S. bipunctatum* occurring in Palestine is represented in the National Collection by a solitary ♀, which differs from the typical form in having the legs much more extensively infuscated; *inter alia* the front femora, except their extreme tips, are deep mouse-grey, the hind femora are broadly banded with dark brown before their distal extremities, and the front and hind tibiae, in addition to their dark tips, are each banded with dark brown just beyond the base. Apart from the details mentioned, there are no noticeable differences from the typical form. The type of this variety, which, in honour of its discoverer, may be termed *Simulium bipunctatum* var. *buxtoni*, var. n., was taken at Jericho, 1.i.1922 (*P. A. Buxton*), and subsequently presented to the British Museum by the Imperial Bureau of Entomology.

Family TABANIDAE.

Subfamily PANGONIINAE.

Genus **Silvius**, Meigen.

**Silvius irritans,** Ric. (fig. 2).

*Silvius irritans*, Ricardo, Ann. Mag. Nat. Hist. (7), viii, p. 292 (1901).

*Silvius unicolor*, Becker, Ann. Mus. Zool. Acad. Imp. Sc. St. Pétersb., xvii, p. 588 (1913). [New synonym].

One ♀, Hit, R. Euphrates, vii.1920; one ♀, Ramadi, R. Euphrates, 9.viii.1920, "in horse lines"; a third ♀, Ramadi, ix.1920: all collected and presented by *Major A. D. Fraser*, who states in a field-note that the "eyes are golden-green, with dark brown markings" (fig. 2).

The typical series (seven ♀♀) of this species, which is in the British Museum, was taken in 1884–85 in Khorasan, Persia, and in the Hari-rud Valley, Afghanistan, by Dr. J. E. T. Aitchison, Naturalist of the Afghan Delimitation Commission, who writes (Trans. Linn. Soc., London (2) v, Zool., p. 132, 1889):—"Near Mount Do-Shakh my ponies were nearly driven mad with the numbers of this very small species; although in ones or twos they did not give much trouble, when in large numbers, as I saw them, they were extremely irritating to the cattle, chiefly attacking the head and fore legs."

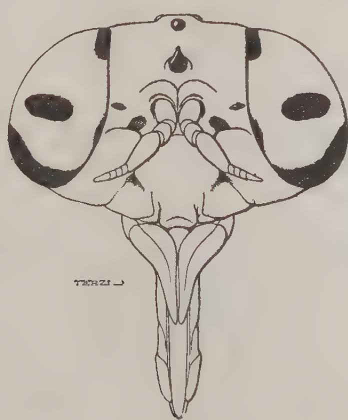

Fig. 2. Head of *Silvius irritans*, Ric., ♀, from in front, showing frontal callus, bare flecks or spots near base of antennae, and eye-markings.

In the case of the typical series of *S. irritans*, all the specimens belonging to which are denuded and shrivelled through having originally been preserved in alcohol, the ground-colour of the dorsum of the abdomen is pinkish cinnamon, with conspicuous slate-black markings as follows:—a large, rounded, median blotch on the second (visible) tergite, not extending to the hind margin, and deep transverse bands on the third and three or four following tergites, each band occupying the anterior three-fourths of the segment; in the case of the third (sometimes also in that of the fourth) tergite the band may be twice interrupted, so as to form a transverse series of three discontinuous blotches; certain specimens show an ill-defined, dusky, median blotch on the first (visible) tergite, projecting somewhat beyond the hind margin of the scutellum. Similar abdominal markings, largely concealed by the coat of pale olive-buff pollen with which head and body in this species are normally covered, are

exhibited by one of Major Fraser's specimens from Ramadi. In the other example from the same locality and in the ♀ from Hit the dorsum of the abdomen is practically unicolorous pinkish buff or light ochraceous-buff, though in the former specimen there is a trace of a dark blotch on each side of the anterior border of the fourth and two following tergites, while the specimen from Hit shows an ill-defined dusky median blotch on the second (visible) tergite. As regards dark leg-markings, the Mesopotamian specimens exhibit considerable reduction in comparison with those from Khorasan and Afghanistan; in particular the blackish-brown area at the distal extremities of the front tibiae is much less extensive, while the front tarsi, instead of being uniformly black or blackish brown, have the first segment blackish brown only at the tip, while the following three segments are more or less distinctly ochraceous-buff at the base. The first and second segments of the antennae are also less infuscated in the Mesopotamian examples than in those belonging to the typical series. While it is clear, however, that, in markings at any rate, *S. irritans* is subject to variation in different parts of its area, there can here be no question of specific difference, as is at once evident on examining the frontal callus and the four small bare flecks near the base of the antennae (fig. 2).

*Silvius unicolor*, Becker, the identity of which with *S. irritans*, Ric., leaves no room for doubt, would appear to represent a form of the species with unicolorous abdomen and femora marked with broad brown bands on their distal halves, or even more extensively infuscated. The four ♀♀ constituting the typical series of this variety were obtained in Persian Baluchistan.

## Genus **Chrysops**, Meigen.

**Chrysops simillima**, sp. n. (fig. 3).

♀.—Length (two specimens), 7·75 to 8·6 mm.; width of head, 2·4 to 2·5 mm.; width of front at vertex, 0·8 to 1 mm.; length of wing, 6·5 to 7·4 mm.

*In ♀ sex, at any rate, very closely resembling* C. punctifera, *Lw.; agreeing therewith in coloration of body and legs as well as in abdominal markings, but distinguishable by the wing-markings (fig. 3), in which, while they present a general agreement with those of the species mentioned, the proximal infuscation in the first basal cell is confined to the extreme base instead of occupying at least half the length of the cell. When examples of* C. simillima *are compared with Palestine specimens of* C. punctifera, *the hair on the dorsum of the thorax (including the scutellum) appears shorter and paler, while the front tibiae (viewed from the side) are more swollen; in a comparison with Algerian representatives of* C. punctifera, *however, these differences are less noticeable.*

*Head* pale olive-buff pollinose, clothed with similarly coloured or pale yellowish hair, which is longer on basioccipital region; front in ♀ slightly broader at its lower extremity than at vertex; *frontal callus* shining black, transversely elongate, fusiform or elliptical oval with blunted ends, about twice as wide as its greatest depth, but widely separated from eye on each side; ocelli surrounded by a more or less sharply defined, blackish area; face with a pair of shining, sepia-coloured *facial tubercles*, each connected with lower margin of clypeus by usual narrower downward extension; jowls with a larger or smaller shining black area below (not in contact with) each eye; proximal segment of *palpi* neutral grey or smoke-grey, clothed with hair similar to that on adjacent region of head, distal segment cinnamon-buff or tawny-olive, moderately swollen proximally, then acuminate, clothed on outer side with short glistening, pale hairs; first segment of *antennae* ochraceous-tawny (sometimes brownish at distal extremity), elongate, straight and cylindrical, not swollen, clothed above with minute black hairs and below with pale hairs, second segment blackish brown (sometimes paler at base), about one-sixth shorter than first segment and with a similar hairy covering, third segment black, rather longer than first. *Thorax*: dorsum, including scutellum, light olive-grey pollinose, pleurae, pectus, and a broad lateral border on each side of scutum pale olive-buff pollinose, dorsum with a pair of broad,

semi-shining, admedian longitudinal stripes, extending in each case from a short distance behind upper extremity of humeral callus to inner angle of posterior extremity of postalar callus, dorsum of scutum also exhibiting a narrow, dusky, median longitudinal line, not reaching either front or hind margin ; dorsum clothed (more thinly on dark stripes) with short, appressed, glistening, Naples-yellow hairs, pleurae clothed with longer, fine, silky, whitish hair. *Abdomen* warm buff, first and second segments paler (Naples yellow), dorsum with blackish-brown markings as shown in fig. 3, last three tergites mainly deep olive-buff pollinose ; venter with last three segments, except hind borders, infuscated (deep olive), second (visible) and third sternites sometimes each with a narrow, deep mouse-grey, interrupted median longitudinal stripe, fourth sternite with a similarly coloured, more or less well-defined, median blotch resting on base but not reaching hind margin ; abdomen clothed with short,


Fig. 3. *Chrysops simillima*, Austen, ♀.

appressed, glistening Naples-yellow hairs, dark markings on third and fourth tergites sometimes clothed mainly with minute black hairs. *Wings* with mummy-brown (in life perhaps blackish-brown) markings as shown in fig. 3, there being a large and well-defined clear " window-pane " in discal cell (in case of type and paratype, at any rate, communicating more or less distinctly with clear space in fifth posterior cell), and apical fleck (*Spitzenfleck* of German writers) being broader than costal border ; infuscation at base of second basal cell less extensive than corresponding infuscation in wing of *C. punctifera*, Lw. (for infuscation at base of first basal cell see fig. 3, and diagnosis in italics above). *Squamae* pale pinkish-buff, their borders paler. *Halteres* seal-brown or clove-brown, stalks sepia-coloured. *Legs* : front coxae pinkish-buff, pale olive-buff pollinose on anterior surface, middle and hind coxae lighter or darker greyish pollinose, all coxae clothed with pale hair ; trochanters blackish brown ; femora ochraceous-tawny, clothed with pale (cream-buff) hair (extreme tips clothed,

at least in part, with minute black hairs), tips of femora blackish brown; tibiae cinnamon-buff, front pair distinctly swollen and their distal extremities (approximately distal halves) blackish brown, extreme bases of all tibiae and extreme tips of middle and hind pairs also blackish brown, paler area of front tibiae clothed on extensor surface and outside with appressed, glistening, ochreous hairs, infuscated area and inner surface of front tibiae clothed with minute black hairs, middle and hind tibiae clothed with cream-buff hair, their extreme tips clothed with minute black hairs; front tarsi uniformly black, middle and hind tarsi blackish brown, bases of second and third segments of middle and hind tarsi, as also first segments except their tips, cinnamon-buff; tarsi clothed with minute black hairs, upper surfaces of first segments of middle and hind pairs except their tips, and of extreme bases of second and third segments of middle and hind pairs clothed mainly with appressed, glistening, cream-buff hair.

Hawizeh Amara and Ramadi. Holotype, Hawizeh Amara, 18.vii.1918 (*P. A. Buxton*; presented by the Imperial Bureau of Entomology); paratype, Ramadi, R. Euphrates, August 1920 (*Major A. D. Fraser*).

Owing to the presence of a clear "window-pane" in the discal cell, the species described above belongs to Kröber's Group *Heterochrysops*,* of which *C. punctifera*, Lw., is also a member. From a second representative of the same group, *C. beckeri*, Kröber (*loc. cit.*, p. 135, pl. ii, fig. 60), the type of which was obtained in Turkestan, the new species is distinguishable, *inter alia*, by the dark stripes on the dorsum of the thorax being somewhat dull, instead of shining black; by the narrowness of the dark brown costal border on the wings, this border being distinctly narrower than the apical fleck instead of being of equal breadth; by the first basal cell being infuscated (with a faint brownish smear) at the extreme base, as well as conspicuously at the tip, instead of having the latter alone brown; and by the front femora being clothed with black hairs only at the tips, instead of on the lower surface generally.

Finally, it may be noted that a solitary ♂ in the National Collection, 8 mm. in length, which is in all probability to be assigned to *Chrysops simillima*, while practically identical in outward appearance with the ♂ of *C. punctifera*, Lw., even when subjected to an extremely close scrutiny, is nevertheless distinguishable owing to the shape of the shining black facial tubercles. In the specimen referred to, the areas in question, which are larger than the corresponding areas in the case of *C. punctifera* ♂, have their lower margins horizontal (instead of running obliquely upwards and outwards), so that the angle formed with the outer margin in each case is to all intents and purposes a right angle. Besides the differences mentioned, the lateral spots on the second (visible) abdominal tergite, in addition to being Naples yellow or cream-coloured, and therefore paler than is usually the case in *C. punctifera* ♂, have their inward extensions narrower, though whether these features are constant it is at present, of course, impossible to say. The ♂ under discussion was taken at Tonooma (on left bank of Shatt el Arab), Basra area, 20–26.ii.1919 (*Captain P. J. Barraud*: presented by the Imperial Bureau of Entomology).

It only remains to add that the species described above is doubtless that which is referred to and described by Major Patton (*loc. cit.*, p. 741) as *Chrysops punctifera*, Lw.

## Subfamily Tabaninae.

### Genus **Tabanus,** Linnaeus.

**Tabanus arabicus,** Macq.

Two ♂♂, three ♀♀, Daurah, R. Tigris, five miles below Baghdad, 23–30.v.1920 (*Major A. D. Fraser*); one ♀, Kurna, R. Tigris, May 1918 (*P. A. Buxton*—presented by the Imperial Bureau of Entomology).

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* *Cf.* O. Kröber, "Die Chrysops-Arten der paläarctischen Region nebst den Arten der angrenzenden Gebiete": Zool. Jahrb., Abt. f. Syst., Geogr. u. Biol. der Tiere, xliii, pp. 42, 50 (1920).

The provenance of this species is given by Macquart simply as "Arabie." The foregoing specimens agree very well with the brief original description, and, so far as it is possible to judge without comparing them with the typical ♂ and ♀ mentioned by the author, there can be little doubt that they have been correctly determined.

The eyes are bare in both sexes, and in the case of the ♂ the area of enlarged facets, which, except posteriorly, occupies approximately the upper three-fourths, is sharply demarcated below; posteriorly the border of small facets diminishes progressively in width from below upwards, until, apart from distinctions caused by colour, it merges more or less imperceptibly into the larger facets (here greatly reduced in size) in the region of the vertical triangle. In the case of the ♀ the eyes are marked with three purple bands. The front in the same sex is of moderate width above and narrower below, and there are two dark brown or blackish-brown frontal calli, the lower of which is large and oval or oblong in shape, while the upper callus is a more or less linear prolongation from the lower. In both sexes the dorsum of the abdomen exhibits a dusky, median, longitudinal stripe, normally more or less concealed by a continuous series of pale-haired, olive-grey triangles. Between median stripe and lateral border on each side, and not in contact with either, is a longitudinal series of oblique, roughly elongate-ovate, pale-haired spots, those forming the respective pairs being situated on the first (visible) to the sixth tergites inclusive, and extending the full length of the segment in each case.

Macquart, at the end of his original description (Mém. Soc. roy. Sc. Agric. Arts Lille 1838, iii, p. 299, 1838), states that *T. arabicus* resembles *T. graecus*, Meig. (*sic*). If by *T. graecus*, "Meig.," the homonymous Fabrician species is intended, the comparison is unfortunate, since, apart from family and generic characters, there is no resemblance whatever between the two.

**Tabanus fumidus,** sp. n. (figs. 4, 5).

♀.—Length (three specimens), 11·6 to 14·8 mm.; width of head just over 4 to 5 mm.; width of front at vertex, 0·6 to 0·75 mm.; length of wing, 9·2 to 11 mm.

*Smallish, smoke-grey species, with two frontal calli in ♀ and bare eyes; front in ♀ of moderate width; dorsum of thorax unicolorous, with little or no trace of longitudinal stripes; dorsum of abdomen with darker markings, as shown in fig. 4; wings hyaline, with an appendix to anterior branch of third longitudinal vein.*

*Head*: front and subcallus smoke-grey pollinose, former clothed with minute cream-coloured hairs, which at sides of and above upper frontal callus are sometimes mixed with or even largely replaced by minute black hairs, no trace of an ocellar tubercle; a faint and ill-defined, sepia-coloured, horizontal band connecting base of each antenna with corresponding eye; face, jowls and occiput pallid neutral grey pollinose or whitish pollinose, the two former and basi-occipital region clothed with silvery-white hair, hind margin of occiput fringed above with short, whitish hairs; *front* in ♀ somewhat narrower below, about four and a half or five times as long as its breadth at lower end; *frontal calli* black or blackish brown, lower callus large, shining, quadrate, only separated from eye on each side by narrowest possible pollinose interval, its lower margin straight and not descending below level of inner angles of eyes, upper frontal callus less shining and less convex, not connected with lower and, when completely denuded, sharply defined and more or less scutiform; *eyes of ♀ in life* bronze-green, without bands; *palpi* cream-coloured, proximal segment clothed with hair like that on jowls, distal segment in ♀ sharply acuminate, strongly swollen at base as seen from side, clothed on outer side with minute, appressed, silvery-white hairs, occasionally interspersed with a few minute, black hairs; first segment of *antennae* (see fig. 5*a*) tawny-olive, strongly swollen distally, with upper distal angle conspicuously produced and embracing second segment, first segment clothed with glistening cream-coloured or pale Naples-yellow hairs (on lower distal angle and under surface with longer whitish hairs); second segment of antennae

ochraceous-tawny, small, with its upper distal angle strongly produced ; third segment of antennae ochraceous-tawny or orange-cinnamon-coloured, annulate portion sometimes brown or brownish, equal in length to about three-fourths of expanded portion, latter in ♀ fairly deep a little before middle, and with a blunt, rounded angle on upper margin. *Thorax* : dorsum (including scutellum) smoke-grey pollinose, clothed with fine, short, silky, appressed drab-coloured hair (in certain places, as on fore-border of scutum, lateral borders of scutellum, and in region of admedian, longitudinal thoracic stripes seen in many species of *Tabanus*, replaced by paler hair), hair immediately above base of wing and on anterior extremity of postalar callus on each side longer and whitish ; ante-alar tubercle on each side vinaceous buff, clothed with whitish or yellowish hair, intermixed below with fine and fairly long black hairs ; pleurae and pectus pale neutral grey pollinose, clothed with fine whitish hair. *Abdomen* : second (visible) and three (or four) following tergites each with a pair of admedian, elongate, slightly oblique blackish-brown

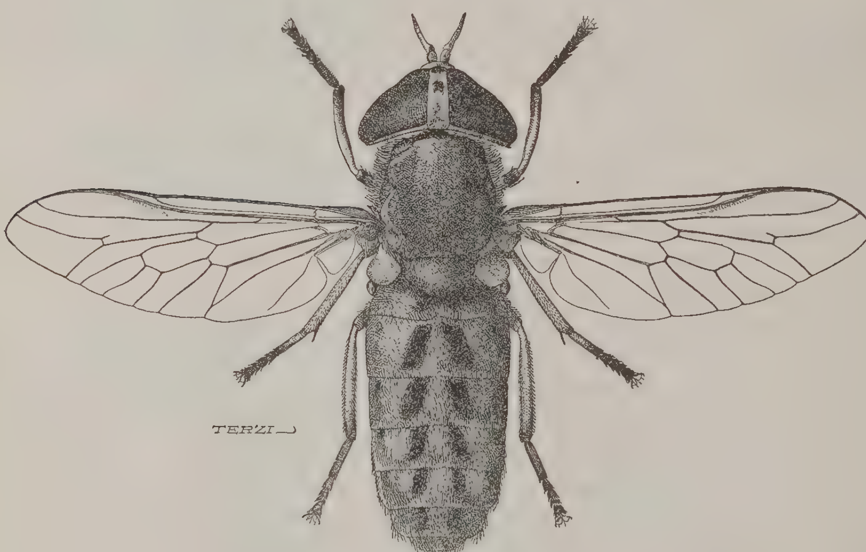


Fig. 4. *Tabanus fumidus*, Austen, ♀.

marks, as seen in fig. 4, resting on front margin in each case but not reaching hind border, second and two (or three) following tergites also each with a small, oblique, more or less distinct blackish-brown fleck near each lateral extremity of the fore border, and near or resting upon anterior margin in each case ; ground-colour of sides of second and third, or second, third and fourth tergites sometimes vinaceous buff ; lateral extremities of first (visible) tergite clothed with fine whitish hair of moderate length, lateral extremities of five following tergites clothed with silvery white hair, short and appressed in case of second and third, longer on the lateral margins of the other three tergites, dark markings clothed, at least in part, with minute, appressed black or blackish-brown hairs, hind border of terminal segment fringed with fairly long, fine black hairs, sometimes mixed with pale hairs, dorsum clothed elsewhere with minute, appressed, pale olive-buff or ivory-yellow hairs ; ventral surface of first three or four (visible) segments uniformly smoke-grey pollinose, two following sternites, except hind margins, usually darker (mouse-grey), ventral surface of first

six segments clothed with minute, appressed, glistening whitish or silvery white hairs, in case of sixth sternite sometimes interspersed with longer blackish hairs, ground-colour of hind margins of second to fifth sternites inclusive ivory-yellow, hind margin of sixth sternite cream-coloured, hind margins of fourth and two following sternites clothed with longer whitish hair, seventh sternite deep mouse-grey or dark mouse-grey, clothed with usual coarse, erect, black hair. *Wings*: costa mummy-brown, other veins tawny olive or light sepia-coloured; *stigma* colourless, scarcely distinguishable. *Squamae* pale pinkish-buff, fringed with fine whitish hair. *Halteres* pale ochraceous-buff, knobs sometimes light buff or ivory-yellow. *Legs*: coxae pale neutral-grey pollinose, clothed with fine whitish or silvery white hair; femora, except tips which are cinnamon-buff, neutral grey pollinose, clothed with silvery white hair, middle femora sometimes entirely or mainly cinnamon-buff pollinose, mottled with neutral grey; tibiae cream-coloured or cream-buff (distal thirds or rather less than distal halves of front pair blackish-brown or black), clothed with short silvery white hairs, extreme tips of middle and hind pairs, or at any rate of latter, brownish, at least on inner side; front tarsi blackish-brown or black, not noticeably expanded or fourth segment very slightly so; middle and hind tarsi mummy-brown and clothed above with minute black hairs, first segment in each case, except tip, more or less cream- or cinnamon-buff-coloured, and clothed above, at least in part, except distal extremity, with minute, appressed, silvery white hairs; hind tarsi, except tips of first four segments, sometimes cinnamon-buff, second and following segments of middle tarsi distinctly expanded.

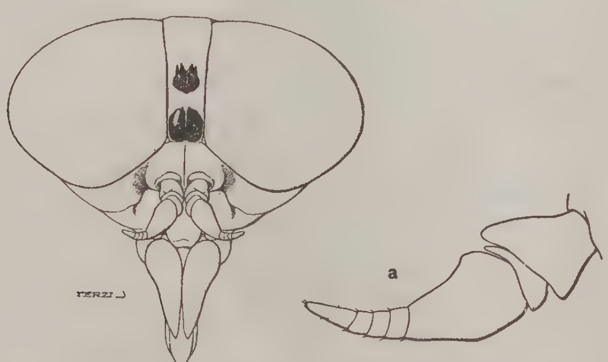


Fig. 5. Head of *Tabanus fumidus*, Austen, ♀, from in front; *a*, antenna, from the side.

Hit and Anah, R. Euphrates (*Major A. D. Fraser*). Holotype, Hit, 28.vii.1920; two paratypes, Anah, 4.viii.1920, "flying round lamp at night."

In the ♀ sex, at any rate, the species described above superficially somewhat resembles *Tabanus pulverifer*, Walk. (see below), the typical series of which was obtained seventy-two years ago at Baghdad (*W. K. Loftus*). From the ♀ of its congener in question that of *T. fumidus* is, however, distinguishable, *inter alia*, by the front being, on the whole, somewhat narrower; by the upper frontal callus being more concentrated and more sharply defined; by the eyes being unbanded; by the upper distal angle of the first segment of the antenna not being dark brown; by the smoke-grey median triangle on the dorsum of each abdominal segment, from the second (visible) to the fifth inclusive, being broader and anteriorly more bluntly truncated; by the appendix to the anterior branch of the third longitudinal vein being longer; and by the middle and hind femora not being entirely pale (pinkish buff).

The ♀ of *Tabanus fumidus* likewise somewhat resembles that of *T. accensus*, Austen (Bull. Ent. Res., x, pt. 3, p. 309, figs. 11, 12, April 1920), from which, on the other hand, it may be distinguished at once by the absence of eye-bands and of definite thoracic stripes, and by the presence of an appendix to the anterior branch of the third longitudinal vein.

From the ♀ of *T. pallidipes*, Austen (*ibid.*, p. 316, figs. 15, 16)—a species which, like *T. accensus*, Austen, has as yet been met with only in Palestine—that of *fumidus* is distinguishable forthwith by its much broader front.

**Tabanus glaber,** Big.

One ♂, precise locality unknown, 1917 (*Dr. A. Balfour, C.B., C.M.G.*) ; three ♀♀, Nasiryeh, R. Euphrates, September–October 1916, "biting camel" (*Major W. S. Patton, I.M.S.*) ; one ♀, Amara, R. Tigris, 22.x.1918, "on bullocks," and fourteen ♀♀, same locality, 27.x.1918 (*P. A. Buxton*—presented by the Imperial Bureau of Entomology).

The type of this species (*ex coll.* J. Bigot ; *ex coll.* G. H. Verrall), which, it may be noted, is from Afghanistan and not (as stated by Kertész, Cat. Dipt., iii, p. 246, 1908) from "India or.", is now in the National Collection. The latter also contains a series of ♀♀ of *T. glaber* from Pad-i-Sultan, Helmund R., Afghanistan, 1884–85 (*Dr. J. E. T. Aitchison*), and a further example of the same sex from Kashgar, Eastern Turkestan, 13.viii.1888 (*Dr. Lansdell*).

In the Helmund Valley, Afghanistan, according to Dr. Aitchison (Trans. Linn. Soc., Lond. (2) v, Zool., p. 131, 1889), *T. glaber* bites horses severely.

**Tabanus inaequatus,** sp. n. (figs. 6, 7).

♀.—Length (four specimens), 12 to 13·6 mm. ; width of head, 4 to 4·4 mm. ; width of front at vertex, 0·4 to just over 0·5 mm. ; length of wing, 10·5 to 11·4 mm.

*Small species, with, in ♀, rather narrow front, two frontal calli, bare eyes marked with three purple bands, unicolorous, dark olive-grey, unstriped thorax, and ochraceous-tawny, cinnamon- or light cinnamon-coloured abdomen, with infuscated apex and more or less distinct, sometimes sharply defined, sometimes greatly attenuated and widely interrupted, narrow, dark, median, dorsal longitudinal stripe.*

*Head* : front dark olive-buff pollinose, clothed with minute, appressed, Naples-yellow hairs, sometimes interspersed in vicinity of vertex with a few minute black hairs ; only a slight indication of an ocellar tubercle, but *anterior ocellus distinctly visible* (at least in typical series—see fig. 7*a*) ; subcallus olive-buff or pale olive-buff pollinose ; face and jowls pale smoke-grey pollinose, clothed with whitish or yellowish-white hair ; occiput light olive-grey pollinose, clothed below with whitish hair, hind margin of occiput fringed above with short, yellowish hair ; *front* in ♀ of uniform or nearly uniform width, about five and a half times as long as its breadth at lower end ; *lower frontal callus* mummy-brown or blackish brown, large, narrowly separated from eye on each side, roughly quadrate in outline, its lower margin straight and not descending below level of inner angles of eyes, upper angles more or less rounded off, upper margin somewhat irregular and sometimes decidedly shorter than lower ; *upper frontal callus* black, elongate, fusiform, connected with or narrowly separated from lower callus ; *palpi* in ♀ cream-buff or cream-coloured, proximal segment clothed with yellowish or yellowish-white hair, distal segment elongate, tapering to a blunt point or acuminate, not greatly swollen proximally as seen from side, clothed on outer surface with minute, appressed, Naples-yellow or cream-coloured hairs, mixed with a larger or smaller number of minute black hairs ; first and second segments of *antennae* in ♀ (fig. 7*b*) cinnamon-buff, first segment more or less expanded distally, and partly embracing second segment, clothed on upper surface, or at least on upper distal angle, sometimes also on entire distal extremity, with minute black hairs,

first segment clothed otherwise with cream-coloured hairs; upper distal angle of second segment of antennae slightly or only moderately produced, distal margin of second segment clothed with minute black hairs; expanded portion of third segment of antennae tawny or orange-cinnamon-coloured (sometimes brownish towards distal extremity), of moderate depth proximally, and with a blunt or rounded angle on upper margin shortly before middle, annulate portion of third segment blackish brown, elongate, approximately as long as expanded portion. *Thorax*: dorsum, including scutellum, clothed with minute, appressed, glistening Naples-yellow hairs, postalar calli clothed beneath with longer yellowish-white hairs; ante-alar tubercles cinnamon-buff, clothed above with silky, glistening Naples-yellow hair, mixed with some erect black hairs, and below with longer, outstanding black hairs; pleurae and pectus smoke-grey pollinose, clothed with fine, silky, whitish or yellowish-white hair, mixed on upper portion of mesopleurae with a certain number of fine black hairs. *Abdomen*: dorsum marked as shown in fig. 6, but dark neutral grey, median, longitudinal stripe, which commences at base of second (visible) segment, is often more or less distinctly

Fig. 6. *Tabanus inaequatus*, Austen, ♀.

and widely interrupted on hind borders of second to fourth tergites inclusive (at least as seen when viewed at a low angle from behind), and is sometimes much narrower; first (visible) tergite with a pair of admedian, dark neutral grey spots, in contact with one another or narrowly separated in middle line, lying on each side of tip of scutellum or just beyond it, and widely separated from hind margin of segment; hind margins of second and following tergites, except last, more or less distinctly light greyish-olive pollinose; last two or last three tergites mainly dark neutral grey, that is, with exception of lateral extremities and hind margins in case of fifth and sixth tergites, and with exception of lateral extremities in that of seventh, although fifth tergite, even when its infuscation is not confined to median stripe, often shows a large, ill-defined, paler (more or less ochraceous-tawny) blotch on each side of region of latter; first six (visible) tergites clothed partly with minute, appressed, glistening Naples-yellow hairs, which, *inter alia*, form a more or less distinct pale longitudinal stripe down centre of median dark stripe, partly with minute black hairs, latter of which are situated especially on each side of median dark stripe on second and third or second to

fourth segments inclusive ; seventh tergite clothed mainly with longer fine black hairs, similar hairs, interspersed with longer fine pale hairs, being usually present on lateral extremities and posterior angles of the three preceding segments ; ventral surface of first five or first six (visible) segments cinnamon- or pinkish-cinnamon-coloured, without slightest trace of a dark median longitudinal stripe, hind margins of second to sixth sternites inclusive pale (cream-coloured or pale pinkish-buff), sixth sternite, except lateral extremities and hind margin or hind border, often mouse-grey or deep mouse-grey, seventh sternite dark mouse-grey or blackish mouse-grey, clothed with usual coarse, erect, black hair, remainder of venter clothed with minute, appressed, glistening, Naples-yellow or cream-coloured hairs, which on sixth sternite are largely intermixed with longer black hairs, a certain number of black hairs also often present on fifth sternite. *Wings* with a distinct light drab or brownish tinge ; veins light sepia-coloured or tawny-olive, anterior branch of third longitudinal vein without an

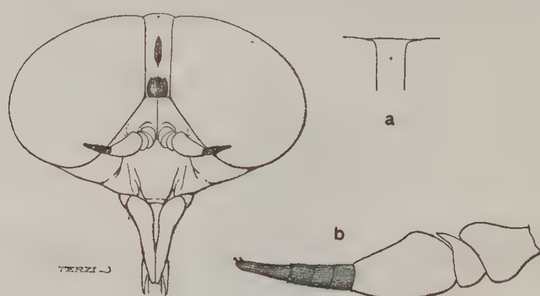


Fig. 7. Head of *Tabanus inaequatus*, Austen, ♀, from in front ; *a*, anterior ocellus ; *b*, antenna from the side.

appendix ; *stigma* colourless, inconspicuous. *Squamae* pinkish-buff, their borders light cinnamon-buff. *Halteres* : stalks cinnamon-buff, knobs pale pinkish-buff or ivory-yellow. *Legs*, except tarsi, ochraceous-tawny or cinnamon-coloured, front tibiae brownish towards distal extremities, extreme tips of hind tibiae also sometimes brownish on inner side ; front tarsi mummy-brown, not expanded, middle and hind tarsi cinnamon-brown, in case of hind tarsi first segment and extreme bases of following segments sometimes paler (ochraceous-tawny) ; tarsi clothed with minute black hairs ; distal extremities and upper surfaces of femora, infuscated area of front tibiae, and distal extremities and extensor surfaces (at least in part) of middle and hind tibiae, as also flexor surface in case of hind tibiae to a greater or less extent, clothed, at least in part, with similar hair ; legs otherwise clothed with pale (light buff or cream-buff) hair, longer and finer on coxae and lower sides of femora, as also on outer edge of extensor surface in case of hind tibiae, elsewhere for most part short, appressed and glistening.

Amara and vicinity, 18.vii.1918 (*P. A. Buxton*).

Owing especially to the ochraceous-tawny or cinnamon-coloured areas on each side of the dorsum of the abdomen being unicolorous, *i.e.*, devoid in each case of a longitudinal series of greyish pollinose or pale-haired oblique blotches, the species described above cannot, in the ♀ sex at least, be confused with any of its congeners known to the writer. As regards other characters, although presenting a certain superficial resemblance in coloration to *Tabanus acuminatus*, Lw., which is found in Southern and Central Europe and in Siberia, the ♀ of *T. inaequatus*, apart from the apex of its abdomen not being laterally compressed, is at once distinguishable from that of the species mentioned by its bare eyes, much narrower front, much more attenuated dorsal abdominal stripe, and pale femora.

**Tabanus (?) laetetinctus,** Beck.

One ♀, north-east of Baghdad, between Ba'qubah and Kizil Robat, v. 1921 (*Major A. D. Fraser*).

In spite of minor discrepancies or uncertainties (*e.g.*, lower frontal callus not "almost in contact with eye-margins"; distal segment of palpi, which is clothed on outer surface with a mixture of minute black and appressed whitish hairs, not "suddenly" attenuate beyond the base; front tarsi, and middle and hind tarsi except at base, more or less mummy-brown), the specimen referred to above may quite possibly belong to the species described by Becker (Ann. Mus. Zool. Acad. Imp. Sc. St. Pétersb., xvii (1912), p. 595, 1913) under the name *Tabanus laetetinctus*, the typical series of which was obtained in Persia (Persian Baluchistan and Seistan).

It may be added that the type of *Tabanus terminalis*, Walk. (obtained in Sinai about 1870, by the late *J. K. Lord*) is no longer to be found in the National Collection. This being the case, the Walkerian species may have to be relegated to the limbo of unrecognisable forms. Becker (*loc. cit.*, p. 596), evidently relying only on Walker's description, states that *T. laetetinctus* shows much resemblance to *T. terminalis*, Walk., and that, had Walker spoken of two frontal calli instead of a single callus, he would have regarded the former as identical with the latter. Be this as it may, Major Fraser's specimen has cream-buff or pinkish-buff halteres, whereas according to Walker the halteres of *T. terminalis* are "piceous at the tips"; in the description of *T. laetetinctus* halteres are not mentioned.

**Tabanus leleani,** Austen.

*Tabanus leleani*, Austen, Bull. Ent. Res., x, pt. 3, p. 312, figs. 13, 14 (April 1920).

One ♂, Ramadi, R. Euphrates, viii.1920 (*Major A. D. Fraser*); seven ♂♂, twelve ♀♀, Hinaidi, near Baghdad, iii.1922, "caught at midday or dusk on walls and window-ledges of donor's Mess" (*Major J. E. M. Boyd*).

This species, the typical series of which was obtained by the author in Palestine, is widely distributed, since, as shown by specimens in the British Museum (Natural History), its range extends at any rate from Algeria, along both shores of the Mediterranean, to the Kangra Valley, Punjab. It should be added, however, that the ♀ from Nasiryeh, R. Euphrates, April–June 1916 (*Major W. S. Patton*), formerly (Bull. Ent. Res., *loc. cit.*, p. 314) attributed by the author to *T. leleani*, appears on further consideration to belong rather to *T. pulverifer*, Walk., under which heading it is accordingly considered in the present paper.

*Tabanus leleani*, Austen, and *T. pulverifer*, Walk., are in fact very closely allied species, which may easily be confused, expecially since it is impossible to formulate any really satisfactory distinctions based on the front and frontal calli in the ♀. An attempt to show mutually distinctive characters, in parallel columns, is made below.

| *Tabanus leleani*, Austen. | *Tabanus pulverifer*, Walk. |
|---|---|
| Larger species, usually with somewhat broader abdomen in the ♀; general coloration of body mouse-grey or blackish mouse-grey, often with little or no trace of paler longitudinal stripes on dorsum of thorax; wings without (occasionally with merest vestige of) an appendix to anterior branch of third vein; femora neutral grey pollinose. | Usually smaller and (at least in case of ♀) generally more slender species; general coloration of body smoke-grey or light greyish-olive, paler longitudinal stripes on dorsum of thorax usually conspicuous; wings normally with a well-developed or at any rate distinct appendix to anterior branch of third vein; femora, at least in part, usually light drab, or drab-grey. |
| ♂.—Small-faceted hind border of eye of uniform width throughout, and everywhere sharply marked off from large-faceted area, latter near its outermost extremity not approaching closer than elsewhere to hind margin of eye; hair fringing upper margin of occiput of moderate length. | ♂.—Small-faceted hind border of eye not quite of uniform width throughout, but somewhat narrower than elsewhere near outer extremity of large-faceted area, where latter is as a rule not quite so sharply marked off from hind border; hair fringing upper margin of occiput very short. |

**Tabanus polygonus,** Walk.

Two ♂♂ (the type and paratype of the species), Baghdad, 1850 (*W. K. Loftus*); one ♂, one ♀, precise locality unknown, 1918 (*Major W. S. Patton*); one ♀, Hawizeh Amara, 18.vii.1918 (*P. A. Buxton*—presented by the Imperial Bureau of Entomology). A note by Major Patton, attached to the specimens collected by him, states that this species is " common all up the Euphrates and Tigris, from May to August."

**Tabanus pulchellus,** Lw. (Subgenus **Ochrops,** Szilády).

One ♂, one ♀, Nasiryeh, R. Euphrates, March–August 1916 (*Major W. S. Patton*); one ♂, precise locality uncertain (*Dr. A. Balfour*); one ♂, seven ♀♀, Amara, R. Tigris, 25.iv.–1.xi.1918 (*P. A. Buxton*—presented by the Imperial Bureau of Entomology); one ♀, north-east of Baghdad, between Ba'qubah and Kizil Robat, May 1921, and one ♂, four ♀♀, Ramadi, R. Euphrates, 6–8.viii.1920 (*Major A. D. Fraser*).

The species under discussion, which was described from specimens collected by its author in Asia Minor, is widely distributed, its range including Algeria, Persia and Afghanistan, while, as correctly pointed out by Szilády (*Ent. Mitt.*, iv, Nr. 4/6, p. 98, 1915), *Tabanus cyprianus*, Ric., the type of which was obtained at Kelopside, Cyprus, is a synonym. The specimens enumerated above vary greatly in size, *i.e.*, from a length of 9 mm. in the case of a ♀ taken by Major Fraser at Ramadi, 8.viii.1920, to a length of 13·6 mm. in that of one of Mr. Buxton's ♀♀ from Amara (28.v.1918). The ♀ caught by Major Fraser in May 1921, between Ba'qubah and Kizil Robat, the length of which likewise exceeds 13 mm., is somewhat abnormal, since the front is broader than usual, and the transverse veins in the wings are not distinctly infuscated. According to field-notes by Major Fraser, in life the eyes of the ♂ of *T. pulchellus* are " very pale green, and unbanded," while those of the ♀ are " pale green," and either " unbanded " or " with one very faint purplish band."

Major Patton notes that this *Tabanus* " occurs all along the River Euphrates "; several of both Mr. Buxton's and Major Fraser's specimens were taken " round a lamp at night "; the ♀ caught by Major Fraser at Ramadi, 6.viii.1920, was " on a mule," while a second ♀, taken by the same collector in the same place on the following day, bears the label " found dead on a screen in tent."

**Tabanus pulverifer,** Walk.

*Tabanus persis*, Ric., Rec. Ind. Mus., iv, p. 251, pl. xiv, fig. 24 (1911) [new synonym].

One ♂, three ♀♀♀ (the ♂ and ♀ types of the species and two paratypes), Baghdad, 1850 (*W. K. Loftus*); one ♀, Nasiryeh, R. Euphrates, April–June 1916 (*Major W. S. Patton*); one ♂, precise locality unknown, 1917 (*Dr. A. Balfour*); one ♂, Daurah, R. Tigris, five miles below Baghdad, 2.vi.1920, " on tent-rope in camp " (*Major A. D. Fraser*); one ♀, Hit, R. Euphrates, 28.vii.1920 (*Major A. D. Fraser*); one ♀, 7.viii.1920, " on horse," two ♀♀, 10, 11.viii.1920, " in horse lines," two ♂♂, 12.viii, 28.ix.1920, " round lamp "—Ramadi, R. Euphrates (*Major A. D. Fraser*).

In a note attached to the ♀♀ taken at Ramadi, Major Fraser writes: " Eyes bronze-green, with fairly broad, rather ill-defined, brownish band."

So far as can be judged from a comparison of the types, *Tabanus persis*, Ric., is a form of *T. pulverifer*, Walk., with black or blackish-brown antennae in both sexes, and a somewhat wider front in the ♀. It may be added that the types of *T. persis*, which are in the British Museum (Natural History) were taken in Seistan, Persia, 9, 10.ix.1906, on a camel and on a horse (*Captain A. S. Leese*).

**Tabanus regularis,** Jaenn.

Four ♂♂, three ♀♀, Daurah, R. Tigris, five miles below Baghdad, 23.v.1920; one ♀, Ramadi, R. Euphrates, viii.1920; two ♂♂, six ♀♀, precise locality uncertain, 1921. All the foregoing taken and presented by *Major A. D. Fraser*, who writes

as follows with reference to the series collected at Daurah, 23.v.1920: " Up to 23.v.1920 I had seen no Tabanidae. These specimens were found in a small plantation at Daurah, about 300 yards from the R. Tigris. The two sexes were present in about equal numbers, and the majority of the flies were sitting on the stems of orange trees; on many of the latter they were in such numbers that from ten to fifteen specimens could be collected by a single sweep of the net.* There was only an occasional fly on the wing; it was near mid-day, and quite hot."

*T. regularis*, Jaenn. (of which the ♀ sex alone has been described), besides being found in South Europe, was met with by the present writer in Palestine (Jordan Valley)†, and has been recorded by Becker‡ as occurring in Persian Baluchistan.

The ♂ of *T. regularis*, which, in the series available for examination, varies in length from 12·2 to 14·5 mm. (the corresponding dimensions in the case of the ♀ being 12 and 15 mm. respectively), in the dried condition, at any rate, presents a certain superficial resemblance to that of *T. leleani*, Austen.§ From the latter, however, *T. regularis* ♂ is distinguishable by the greater narrowness of its posterior orbits in the region of the vertex, and by the fact that the outer extremity of the area of enlarged facets in each eye approaches less closely to the hind margin of the eye itself than is the case in *T. leleani* ♂. While in the latter the upper portion of the posterior orbits forms a conspicuous pale olive-grey edging to the eyes, in *T. regularis* ♂ the corresponding region is so narrow as to be scarcely noticeable. The fringe of hair, too, on the hind margin of the upper posterior orbits in *T. leleani* ♂, although short, is decidedly longer and more conspicuous than the corresponding fringe in *T. regularis* ♂.

**Tabanus spectabilis,** Lw.

One ♀, Hinaidi Cantonment, near Baghdad, viii.1921 (*Major A. D. Fraser*).

This striking and somewhat rare species, the type of which is a ♀ found by its author in the vicinity of Belgrade, has hitherto been met with only in Southern and South-Eastern Europe and North-Western Asia Minor. Major Fraser's specimen appears to represent a variety, in which the pale longitudinal stripes on the dorsum of the thorax are more distinct than in the typical form, while the same region of the body is clothed with very short, appressed hairs, without any conspicuously longer, erect hairs on the area in front of the transverse suture. The uniformly grey venter is devoid of a distinctly marked black longitudinal stripe, and in the wing the first posterior cell is only slightly narrowed at the tip.

**Tabanus sp. incert.—nov. ?**

One ♀, Baghdad, 1849–1852 (*W. K. Loftus*).

This is the specimen briefly described by Walker (List Dipt. Ins. in coll. Brit. Mus., pt. v, Suppl. i, p. 238, 1854) as possibly representing the ♀ sex of *T. polygonus*, with which, however, it nas nothing whatever to do. In size and general facies it is not unlike the ♀ provisionally assigned to *T. laetetinctus*, Beck. (see above), from which, however, it differs, *inter alia*, in the unusual feature of the lower frontal callus being situate well above the level of the inner angles of the eyes; in the upper frontal callus being much larger and entirely unconnected with the lower; in the eyes having three horizontal bands; and in the annulate portion of the third

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* *Cf.* Dr. J. W. Scott Macfie's note (Bull. Entom. Res., iii, p. 223, 1912) on the remarkable occurrence of both sexes of several species of Tabaninae on the branches of a " Chedia " tree at Ilorin, Northern Nigeria. In this case, however, the phenomenon was apparently due to the presence of a scale-insect (*Ceroplastes egbarum*, Ckll.), with which the tree was " heavily infested," and to the honey-dew-like secretion on which the flies appeared to be feeding.

† *Cf.* Austen, Bull. Entom. Res., x, p. 302 (1920).

‡ Ann. Mus. Zool. Acad. Imp. St. Pétersbourg, xvii, p. 596 (1912).

§ *Cf.* Austen, *loc. cit.*, p. 312, figs. 13, 14.

segment of the antenna being much stouter. It may be added that what Walker (*loc. cit.*) calls a third frontal callus is merely a flat, semi-shining and partially denuded area in the ocellar region of the vertex.

Although this individual may well represent an undescribed species, it seems advisable in view of its age and sundry imperfections (including a partly denuded thorax, and the fact that the middle legs are missing and the others more or less damaged) to await the arrival of further material before supplying it with a trivial name.

**Tabanus sufis,** Jaenn.

One ♂, one ♀, Nasiryeh, R. Euphrates, March–June 1916 (*Major W. S. Patton*).

This small species, the type of which was obtained in Nubia, has a wide range which, as shown by specimens in the British Museum (Natural History), extends right across Africa ; besides occurring in Kenya Colony and the Egyptian Sudan, *T. sufis* is found so far west as Northern Nigeria.

**Tabanus sp. incert.** (allied to **T. sufis,** Jaenn.).

Two ♀♀, Fao, Persian Gulf, 29.iv.1892 (*W. D. Cumming*).

The above-mentioned specimens, which measure from 10 to 11 mm. in length, very possibly represent a local race of *T. gerkei*, Brauer, from which they are distinguished chiefly by the ground-colour of the abdomen and femora being pale. While presenting an unmistakable general resemblance to *T. sufis*, Jaenn., with which they agree in the shape and dimensions of the ♀ front, they are distinguishable from that species, *inter alia*, by the upper border of the occiput being considerably swollen and much broader, and by the wing-veins or portions of wing-veins—such as the anterior transverse vein, base of the anterior branch of the third longitudinal vein, etc.—that are conspicuously darkened in the case of *T. sufis*, showing little or only a very slight trace of infuscation. As in *T. sufis*, the anterior branch of the third longitudinal vein is provided with a well-marked appendix, which appears to vary in length in different individuals.

It may be added that the typical form of *T. gerkei*, Brauer, would appear to extend right across Russia from south to north, since, according to Brauer (Denkschr. K. Akad. Wiss., math.-naturw. Cl., Wien, xlii, p. 205, 1880), it is found in South Russia and the Caucasus, while the British Museum possesses a specimen from Finland.

# CERTAIN NURSERIES OF INSECT LIFE IN WEST AFRICA.

By J. W. S. Macfie and A. Ingram.

When studying the bionomics of certain species of the Ceratopogoninae in the Gold Coast, samples of material collected from different sources, where it seemed likely that the early stages of these small insects might be passed, were brought to the laboratory for examination. The samples were chiefly taken from rot-holes in live trees, from cut bamboo stumps, from decaying logs, from old canoes, from the edges of pools and puddles, from crab-holes, and from the bases of banana plants.

Each sample on arrival was placed in a wide-mouthed glass jar, and—the mouth of the jar having been covered with a glass plate—was kept under observation for at least seven days, after which period, if no insect had hatched and no larva or pupa had been seen, it was thrown away. Experience having proved that dry samples were unproductive of insects, and that complete submergence of the material in water drowned certain larvae, it was found necessary to arrange the samples in the jars in such a way that they were damp but did not become water-logged. This was effected by pouring water into the jars to a depth of a quarter to half an inch, and by heaping up the material at one side ; in this way it was possible to rear terrestrial and aquatic larvae simultaneously. Many of the samples proved barren ; on the other hand, those from certain sources were found to be teeming with insect life. The most productive material examined was banana fibre in a state of decomposition, such as can readily be found at the base of most mature banana plants ; the fibre must be of a brown hue and somewhat softened, hard cream-coloured fibre having been found to yield so few insects as scarcely to be worth the trouble of collection. How prolific of insect life such decaying banana fibre can be, may be judged from the fact that over a hundred specimens of Ceratopogoninae alone, comprising at least five species, were obtained from a single sample of this material, which weighed about $1\frac{1}{2}$ lb., in the course of five weeks during which it was under observation. Next in productiveness to banana fibre were the debris collected from rot-holes in live trees and the rotting wood scraped from the ends and sides of old canoes tied to the bank of the river Densu at a village called Oblogo.

As such samples yielded not only Ceratopogoninae, but also other insects, it may be of interest to give lists of the insects which hatched from them, merely as a suggestion of the wonderful assemblage of insect life which may be found in small quantities of decaying vegetable matter in West Africa. It is to be noted that banana fibre and the rotting wood at the sides and ends of canoes are normally habitats of terrestrial larvae, though occasionally they may become suitable for aquatic larvae, as, for example, when the stem of a banana plant has been cut through and the hollow becomes filled with water, or when a canoe becomes filled with rain-water.

### Decaying Banana Fibre.

The following mosquitos and Ceratopogonine midges were reared from decaying banana fibre :—

| Mosquitos. | Ceratopogonine Midges. |
|---|---|
| *Culex* (*Culiciomyia*) *nebulosus*, Theo. | *Culicoides austeni*, C. I. & M. |
| *Eretmopodites chrysogaster*, Graham. | *C. eriodendroni*, C. I. & M. |
| *Aëdes* (*Ochlerotatus*) *apicoannulatus*, Theo. | *C. grahami*, Aust. |
| *Aëdes* (*Stegomyia*) *dendrophilus*, Edw. | *C. inornatipennis*, C. I. & M. |
| | *C. inornatipennis*, C. I. & M., var. *rutilus*, I. & M. |
| | *Dasyhelea flava*, C. I. & M. |
| | *D. fusciscutellata*, C. I. & M. |
| | *D. luteoscutellata*, C. I. & M. |
| | *D. pallidihalter*, C. I. & M. |
| | *D. similis*, C. I. & M. |
| | *Forcipomyia castanea*, Walk. |
| | *F. ingrami*, Cart. |
| | *Forcipomyia* sp. n. |

In addition to these insects two species of Psychodidae, *Telmatoscopus meridionalis*, Eaton, and a small unidentified species, were reared from the same material, one species of Poduridae, and two species of Muscoidea, one apparently a " fruit-fly." Species of the genera *Styringomyia*, *Olbiogaster*, and *Mesochria* were also reared from rotting banana fibre.

### Rotting Wood from Old Canoes.

The following mosquitos and Ceratopogonine midges were reared from rotting wood taken from the ends and sides of old canoes tied to the bank of the river Densu at Oblogo, a village near Accra :—

| Mosquitos. | Ceratopogonine Midges. |
|---|---|
| *Anopheles costalis*, Lw. | *Atrichopogon chrysosphaerotum*, I. & M. |
| *Aëdes argenteus*, Poir. (*Stegomyia fasciata*, F.). | *A. homoium*, I. & M. |
| *Culex decens*, Theo. | *Culicoides schultzei*, End. |
| *Lutzia tigripes*, Grp., var. *fusca*, Theo. | *C. similis*, C. I. & M. |
| | *Dasyhelea flaviformis*, C. I. & M. |
| | *D. fusca*, C. I. & M. |
| | *D. inconspicuosa*, C. I. & M. |
| | *Thysanognathus* (*Prionognathus*) *pseudomaculipennis*, C. I. & M. |
| | *Probezzia pistiae*, I. & M. |
| | *Stilobezzia spirogyrae*, C. I. & M. |

In addition, at least two small species of Chironomidae were reared from this material.

### Rot-holes in Living Trees.

Rot-holes in trees are a most prolific source of mosquitos, and for this reason have attracted the attention of sanitarians ; they are equally objectionable as a source of biting midges and other insects. From material taken at various times from a single

rot-hole in a particular silk-cotton tree (*Eriodendron anfractuosum*) at Nsawam the following mosquitos and Ceratopogonine midges were reared :—

| Mosquitos. | Ceratopogonine Midges. |
|---|---|
| *Culex* (*Culiciomyia*) *nebulosus*, Theo. | *Culicoides accraensis*, C. I. & M. |
| *Aëdes* (*S.*) *apicoargenteus*, Theo. | *C. clarkei*, C. I. & M. |
| *A.* (*S.*) *dendrophilus*, Edw. | *C. confusus*, C. I. & M. |
| *A.* (*S.*) *argenteus*, Poir. | *C. eriodendroni*, C. I. & M. |
| *A.* (*S.*) *luteocephalus*, Newst. | *C. inornatipennis*, C. I. & M. |
| *A.* (*O.*) *apicoannulatus*, Edw. | *C. inornatipennis*, C. I. & M., var. *rutilus*, I. & M. |
| *Toxorhynchites brevipalpis*, Theo. | *C. punctithorax*, C. I. & M. |
| | *Forcipomyia ingrami*, Cart. |

In addition, two species of Psychodidae, *Telmatoscopus meridionalis* and a small species not yet identified, were reared from material from this particular rot-hole, one large species of Chironomidae, and two species of Tipulidae ; a species of cockroach was also found to inhabit this rot-hole.

The larvae of *Anopheles costalis*, Loew, although not found in this particular tree are found occasionally in rot-holes in trees at Accra.

Larvae of *Stegomyia* are especially associated with rot-holes in trees. In a flamboyant tree (*Poinciana regia*) in the laboratory compound there is a rot-hole which is permitted to remain untouched by the sanitary authorities on condition that we keep close watch over it. From this rot-hole we have obtained *Aëdes* (*Stegomyia*) *apicoargenteus*, Theo., *Aëdes argenteus*, Poir. (*S. fasciata*, F.), *Aëdes* (*S.*) *luteocephalus*, Newst., *Aëdes* (*S.*) *metallicus*, Edw., *Aëdes* (*S.*) *simpsoni*, Theo., and *Aëdes* (*S.*) *unilineatus*, Theo.—that is, all the species of the subgenus *Stegomyia* known to occur in Accra.

It would perhaps be more accurate to describe the larvae of this subgenus as frequenting small enclosed collections of water, since they are by no means restricted to rot-holes in trees. *Aëdes argenteus* (*Stegomyia fasciata*), indeed, appears to have become largely a domestic mosquito, laying its eggs in the vessels which accumulate in the vicinity of human habitations. Far from the haunts of man, however, larvae of this species are abundant not only in rot-holes, but also in old calabashes, small rock pools, and similar situations, so that it may well be that its domestic habit is less an adaptation than an accidental occurrence, the result of the great multiplication in and around towns and villages (especially those to which European civilisation has introduced the tin) of just those kinds of situation which the mosquito was accustomed to select as favourable for the development of its larvae, and which, moreover, have the additional advantage that they are not frequented by its natural enemies. Other species appear to be more particular as to the nature of their nurseries, for example, *Aëdes* (*S.*) *vittatus* shows a strong preference for rock pools, and we have not found *A.* (*S.*) *metallicus* and *A.* (*S.*) *unilineatus* except in rot-holes in trees. As has been suggested by one of us (Report of the Accra Laboratory for the year 1916, pp. 28–29), the resistant eggs of *Stegomyia* (and such resistant eggs are not peculiar to *Aëdes argenteus*) are an adaptation not so much to the necessity of tiding over the dry season as to the habit of breeding in small enclosed collections of water, such as rot-holes, which are apt to dry up between rain showers by evaporation or leakage, leaving the eggs that had been deposited on the surface stranded on the sides. This adaptation not only saves the eggs from perishing, but also gives them a decided advantage over newly deposited eggs, for whereas eggs laid directly on the water take a few days (about three days in the case of *Aëdes argenteus*) to hatch, those which have been stranded hatch immediately they are immersed—for instance, by a shower filling up the rot-hole—and the emerging larvae have therefore a better chance of completing their development before the rot-hole or other small collection of water dries up again.

**Associated with** *Pistia stratiotes.*

It may be of interest to add here a short note on the insects we have found associated with the water lettuce, *Pistia stratiotes*, and to give the following list of mosquitos and Ceratopogonine midges which we have reared from plants of this weed taken, with a little of the surrounding water, from pools or river back-waters :—

| Mosquitos. | Ceratopogonine Midges. |
|---|---|
| *Aëdes* (*Ochlerotatus*) *albocephalus*, Theo. | *Atrichopogon ochrosoma*, I. & M. |
| *Aëdomyia africana*, N.-L. | *Culicoides austeni*, C. I. & M. |
| *Anopheles costalis*, Loew. | *C. distinctipennis*, Aust. |
| *A. funestus*, Giles. | *Dasyhelea inconspicuosa*, C. I. & M. |
| *A. mauritianus*, Grp. | *Eukraiohelea africana*, I. & M. |
| *A. marshalli*, Theo. | *E. versicolor*, I. & M. |
| *A. nili*, Theo. | *Parabezzia poikiloptera*, I. & M. |
| *A. pharoensis*, Theo. | *Palpomyia pistiae*, I. & M. |
| *Culex decens*, Theo. | *Thysanognathus* (*Prionognathus*) *pseudomaculipennis*, C. I. & M. |
| *C. guiarti*, Blanch. | *Probezzia pistiae*, I. & M. |
| *C.* (*Micraëdes*) *inconspicuosus*, Theo. | *P. stephensi*, I. & M. |
| *C. quasigelidus*, Theo. | *Ankistrodactylus* (*Schizodactylus*) *par*, I. & M. |
| *Lutzia tigripes*, Grp., var. *fusca*, Theo. | *Sphaeromias litoraurea*, I. & M. |
| *Ficalbia mediolineata*, Theo. | |
| *Mansonioides africanus*, Theo. | |
| *Mimomyia mimomyiaformis*, Newst. | |
| *M. splendens*, Theo. | |
| *Uranotaenia balfouri*, Theo. | |

In addition to these insects several species of CHIRONOMIDAE were reared, and more than one species of SYRPHIDAE.

The list is a formidable one, and particular attention should be called to the fact that it includes six species of *Anopheles*—that is, all the species which are known to occur commonly in this part of the Gold Coast. The association of *Anopheles* with *Pistia* plants has previously been noted. On a former occasion (Bull. Ent. Res., viii, p. 136) we recorded that *A. costalis*, Loew, and *A. marshalli*, Theo., frequented *Pistia*-covered pools. In this connection, however, special mention should be made of the observations of Zetek (Bull. Ent. Res., xi, pp. 73–75), who has found *A. albimanus*, Wied., and *A. tarsimaculatus*, Goeldi, in association with this weed in the Panama Canal Zone, and has discussed the necessity of dealing with the plants.

# IDENTIFICATION OF SOME FIG INSECTS (HYMENOPTERA) FROM THE BRITISH MUSEUM (NATURAL HISTORY).

By Prof. Guido Grandi,

*Portici, Italy.*

Through the kindness of my friend Dr. James Waterston, the Authorities of the British Museum have sent me for examination a certain number of preparations containing some fig insects from various parts of the world. One of the species in this material, *Otitesella digitata*, Westw., has already been studied and figured by me in a recent paper ;* some of the others are dealt with below.

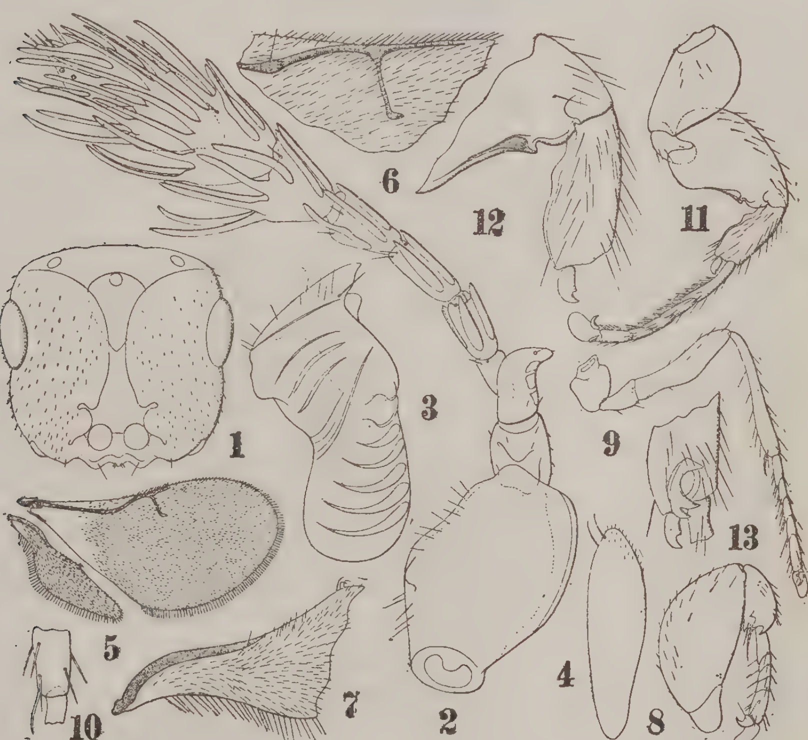


Fig. 1. *Blastophaga quadraticeps*, Mayr, ♀: 1, head from in front, without antennae or mandibles ; 2, antenna ; 3, ventral aspect of mandible ; 4, first maxilla ; 5, wings ; 6, marginal vein and radius of fore wing ; 7, proximal portion of hind wing ; 8, external view of fore leg, without coxa ; 9, middle leg ; 10, distal extremity of tibia of middle leg ; 11, hind leg from inner aspect ; 12, distal portion of femur and tibia of hind leg, showing the special coadaptation ; 13, external view of distal portion of hind tibia, showing subapical dentate process.

* Grandi, G.—Ricostruzione e morfologia comparata dei generi *Otitesella*, Westw., *Sycobiella*, Westw., ed affini.—Boll. Lab. Zool., Portici, xvi, 15 Aprile 1922, pp. 1-58, 21 figs. (*v.* pp. 18-21, figs. i and ii).

**Blastophaga quadraticeps,** Mayr.

Verhandl. d. K.K. zool. bot. Ges. Wien, B., xxxv, 1885, pp. 154, 161, 164, 176, 177.

♀.—General body colour tawny brown, dark in various parts. Base of antennae and legs honey-coloured.*

*Measurements.* Length of head, 0·36 mm. ; width, 0·36 mm. ; length of thorax, including propodeon, 0·64 mm. ; width of thorax, 0·45 mm. ; length of abdomen, 0·70 mm. ; that of the free portion of the terebra, 0·96 mm. ; length of fore wings, 1·22 mm ; width, 0·56 mm. ; length of hind wings, 0·71 mm. ; greatest width, 0·15 mm.

*Head.* The epicranium (fig. 1, [1]) is about as long as broad ; its lateral margins in front of the eyes (taken between the mandibular fossae) are as long as, or a little longer than, the greatest diameter of the eyes and slightly convex. The epistomal edge shows a feeble angular median prominence and two rounded submedian projections. The median posterior chitinised area of the frons is rather limited and hardly reaches to the anterior ocellus. Bristles as in figure. *Antennae* (fig. 1, [2]) with the scape about half as long again as its greatest width ; third joint ending in a laminate process, strongly recurved, rounded off at the apex, and with some subquadrangular areas more strongly chitinised ; fourth joint slightly longer than wide ; fifth joint one-half longer than the fourth and about twice its greatest width, with a few large elongate sensoria, which occupy almost its whole length and project slightly over its distal extremity ; sixth slightly longer than the fifth and about equal in breadth, and with similar sensoria ; seventh almost as long as the sixth, but about twice as broad at its distal extremity, some of its sensoria projecting slightly distally, others for one-third or half their length ; eighth joint a little longer than the seventh but much wider distally, strongly contracted at base and provided with a certain number of sensoria, some of which occupy its whole length and project slightly over its apex ; others, very long, rising from a rather large base at the distal margin, project to a distance equal to once or twice the length of the joint ; others extend along the joint for a certain distance and project strongly, though not so far as the preceding ones. The ninth and tenth joints similar to the eighth, though the ninth is a little longer than either the eighth or tenth, and with similar sensoria. The tenth subfusiform and provided with many long and projecting sensoria. Bristles very few and short, and distributed as in figure. *Mandibles* (fig. 1, [3]) bidentate at the apex. The proximal process about as long as the body of the mandible, broadly rounded posteriorly, and with seven transverse ridges, the first (proximal) has a tooth-like appearance. Bristles as in figure. *First maxillae* (fig. 1, [4]) with a couple of rather short, normally-shaped distal, marginal bristles.

*Thorax.* Pronotum subtrapezoidal, with a few scattered hairs, scutum of the mesonotum almost bare ; scapulae with a submarginal external group of small bristles (six or little more) ; axillae with six to nine submarginal internal hairs ; scutellum with very few (four or five) ; parascutelli bare. Metanotum with few small sublateral hairs.

*Fore wings* (fig. 1, [5, 6]) about twice as long as broad and broadly rounded at the distal extremity ; submarginal twice as long as the marginal and postmarginal ; marginal almost as long as the postmarginal, which ends indistinctly ; radius a little longer than the postmarginal vein and directed slightly obliquely towards the distal extremity of the wing and ending in an elongated dilatation with two sensoria. Costal cell about eight times as long as its greatest width and covered on its distal half with many small hairs. Hairs of the alar disc and fringe as shown in fig. 1, [5] and [6]. *Hind wings* (fig. 1, [5, 7]) a little longer than half the fore wings and about four times as long as broad, narrowing considerably at their distal extremity, where they become abruptly rounded. The neuration becomes indistinct at about half the distance between the

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* Specimens mounted in Canada balsam. For names of colours see Saccardo (P. A.). "Chromotaxia." Patavii, 1912.

base of the wing and the point of the costal margin, where there is a group of three hamuli. Bristles as in the figure.

*Fore legs* (fig. 1, [8]) with the femur about twice as long as its greatest width ; tibia a little less than half the femur and provided on its external aspect with a tridentate process ; tarsus about one and a half times as long as the tibia, and its first joint half the length of the tibia ; pretarsus and bristles as in figure. *Middle legs* (fig. 1, [9, 10]) with the trochanter slightly shorter than the coxa, or about one-third the length of femur ; tibia longer than femur and provided at the distal extremity of its ventral margin with a lancet-like spur which is one-sixth its length ; tarsus a little shorter than tibia ; second and third joint equal and a little shorter than the first ; fourth shortest of all ; the fifth the longest ; pretarsus and bristles as in figures. *Hind legs* (fig. 1, [11–13]) : coxa as long as femur or slightly shorter ; femur with dorsal margin strongly convex and broadly rounded ; tibia just shorter than femur and provided with a very conspicuous compound tridentate armature situated at the distal extremity of its exterior aspect and with a sublaminar and bifid terminal spine (fig. 1, [11–13]). The femur and tibia show a very interesting reciprocating mechanical arrangement. Towards the distal extremity of the ventral margin of the femur there is an angular projection strengthened by a chitinous thickening, which is prolonged proximally, thinning out beyond the middle of the femur and running in a submarginal direction. This projection is followed by an abrupt concavity of the margin and then by a round process. The tibia in the proximal half of its ventral margin has a rounded projection, limited proximally and distally by two slight convexities (fig. 1, [12]). Tarsus twice as long as the tibia ; the length of the first joint equal to three-quarters that of the tibia and of the free ventral margin of second, third, and fourth joints taken together ; fourth joint shortest of all ; fifth about as long as the second ; pretarsus and bristles as in figure.

*Abdomen.* Urotergites sparsely pilose. Cercoids of the ninth urotergite with four bristles, which are longer than the appendage, one of them being twice as long. Projecting portion of terebra a little less than one and a half times as long as the abdomen.

*Geographical distribution.* Three specimens mounted in Canada balsam from Ceylon, collected by Dr. Thwaites in the receptaculi of *Ficus religiosa*, forming part of the material examined by Westwood, who says, on p. 43 of his " Further Descriptions of Insects infesting Figs " (Trans. Ent. Soc., London, 1883, pp. 29–47) : " 1. Both sexes of a species of *Blastophaga*, of which the antennae of the female are strongly clavate, with the terminal joints armed with very strong compressed bristles."

*Observations.* Mayr's material came from Singapore, and was collected by Count Solms-Laubach. This author's description of the ♀ is very superficial.

**Blastophaga williamsi,** sp. n.

♀. Colour of body smoky-brown. Antennae from the fifth joint honey-brown. Mandibles ferruginous. Legs honey-coloured, more or less infuscated.

*Measurements.* Length of head, 0·33 mm. ; width, 0·35 mm. ; length of thorax, including propodeon, 0·60 mm. ; length of abdomen, 0·57 mm. ; length of projecting portion of terebra, 0·50–0·60 mm. ; width of the peritremes of the tracheal spiracles of the eighth urotergite, 0·035 mm.

*Head* (fig. 2, [1]) a little wider than long and slightly developed behind the compound eyes ; its lateral margins in front of the eyes equal in length to the greatest diameter of the eyes and rather converging anteriorly. The epistomal edge with a median angular and two submedian broadly rounded prominences ; eyes moderate, subposterior, three ocelli placed on the vertex in a very obtuse triangle ; hairs and bristles as in figure. *Antennae* (fig. 2, [2, 3]) of eleven joints, of which the last three form the club. Scape about one and a half times as long as its greatest width ; second joint as in figure ; the third divided into two parts, one proximal, somewhat ring-like,

and the other distal, laminate, which thins out at its apex and ends in a small tooth-like spike ; fourth joint twice (or a little less) its distal width ; fifth joint about as long as the fourth and as long as broad ; sixth, seventh, and eighth equal, but increasing slightly in width ; the sixth exactly as long as wide, the eighth wider than long ; all these three distinctly larger than the fifth ; the ninth and the tenth just transverse and as wide as the eighth ; the eleventh longer than broad and somewhat spindle-shaped. All the joints from the fifth to the tenth have, besides various rather long and strong bristles, a certain number of large and long sensoria, which are almost as long as the joints themselves and project rather conspicuously beyond their distal extremities. *Mandibles* (fig. 2, 4) bidentate, with the apical tooth projecting and acute ; ventral surface with about a dozen ridges, transversely obliquely arranged. The proximal process about as long as the mandible, with eleven transverse raised laminae ; the first (proximal) has a tooth-like appearance ; bristles as in figure.

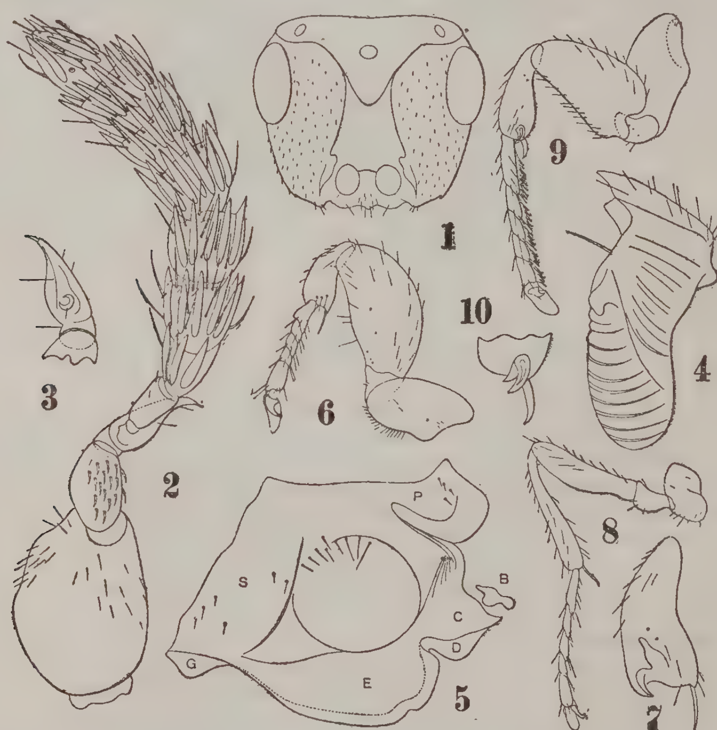


Fig. 2. *Blastophaga williamsi*, Grandi, ♀ ; 1, head seen from in front, without antennae or mandibles ; 2, antenna ; 3, third joint of antenna and distal extremity of second ; 4, ventral aspect of mandible ; 5, left half of sternopleural mesothoracic region (B, posterior basal sclerite ; C, mesopleural alar process ; D, marginal expansion of mesopleura corresponding to epimeral region ; E, epimeral region ; G. mesosternal leg-bearing condyle ; P, prepectus ; S, sternal region) ; 6, front leg (inside) ; 7, tibia of front leg (outside) ; 8, middle leg ; 9, hind leg ; 10, distal extremity of tibia of hind leg.

*Thorax.* Pronotum sparsely pilose. Anterior portion of mesonotum strongly transverse. Scutum bare ; scapulae with a few small submarginal, lateral, external hairs. Scutellum with a submedian irregular group of about fifteen minute bristles ; axillae with three or four hairs along their internal margin ; parascutelli bare and larger than axillae. Sterno-pleural mesothoracic region as in fig. 2, 5.

*Fore legs* (fig. 2, [6, 7]) with the coxa a little less than twice as long as broad; femur slightly less than one and a half times the coxa; tibia half the length of the femur, and provided with an external bidentate expansion and a simple spiniform spur. Tarsus one and a half times as long as the tibia; its first joint about as long as half the tibia and like the fifth; its free ventral margin equal in length to that of the three following joints taken together. Pretarsus and bristles as in figure. *Middle legs* (fig. 2, [8]) with the coxa transverse; trochanter about one-third of femur, which is slightly shorter than tibia; the latter a little shorter than the tarsus and provided with a rather long and spiniform spur. The first joint of tarsus as long as the two following taken together; the fifth as long as the second. Pretarsus and bristles as in figure. *Hind legs* (fig. 2, [9, 10]) with coxa about as long as femur and longer than tibia; the latter provided at its distal extremity with a tridentate complex and a simple tooth-like spur. Tarsus one and a half times as long as tibia; its first joint little longer than half the length of tibia and the following two joints taken together. Pretarsus and bristles as in figure.

*Abdomen.* The urotergites with a certain number of short hairs irregularly arranged; the cercoids of the ninth urite with four relatively long bristles each. The projecting portion of the terebra a little longer than the abdomen.

*Geographical distribution.*—A dozen ♀♀, mostly mutilated, devoid of wings and mounted in Canada balsam; collected by C. B. Williams in Barbados on the 19th April 1915.

*Observations.*—This species, so far as one can judge from the insufficient and incomplete description of Mayr and without the help of the characters of the male, approaches very closely *B. brasiliensis*, Mayr, and *B. bifossulata*, Mayr, from Brazil. From the first, however, it would appear to differ in the distinctly shorter terebra (0·58–0·68 mm. instead of 0·80–0·84 mm.) and the first joint of the fore tarsus, which is half the length of the tibia and not one-third; from the second species in the fourth joint of the antennae, which is twice as long as broad distally (instead of being as long as wide) and in the first joint of the tarsus, which in the Brazilian form is scarcely one-fifth the length of the tibia.

**Ceratosolen fuscipes,** Mayr.

Mayr, Verh. zool. bot. Ges. Wien, xxxv, 1885, pp. 161, 163, 167, 168, pl. xi, fig. 3; Grandi, Boll. Lab. Zool. Portici, xi, 1916, pp. 194–201, figs. v–viii.

Six ♀♀ mounted in Canada balsam and collected by Prof. H. M. Lefroy in India. This species was already known in Java and Ceylon. In the latter island it is found in the receptaculi of *Ficus glomerata*, Roxb. Mayr mentions having examined some specimens collected in Java in *Ficus covellii.*

The terebra of the ♀♀ belonging to the British Museum is a little longer than the abdomen or, rather, somewhat longer (length of gastrum, 0·96 mm.; length of projecting portion of terebra, 1·22 mm.) but is never one and a half times as long as the abdomen.

**Ceratosolen crassitarsus,** Mayr.

Mayr, Verh. zool. bot. Ges. Wien, xxxv, 1885, pp. 161, 163, 171, 172, pl. xi, fig. 7; Grandi, Boll. Lab. Zool. Portici, xii, 1917, pp. 40–46, figs. xiv, xv.

One ♀ and six ♂♂ mounted in Canada balsam and collected by H. N. Ridley in Singapore, Malay Peninsula, occurring in *Ficus roxburghi.* This species was known from the island of Java, where it is found in the receptaculi of *Ficus ribes*, Reinw.

In the British Museum specimens the first joint of the fore tarsus of the ♀ is longer than the following three taken together; in the ♂♂ the tibia of the middle leg is provided at the distal extremity with four spiniform teeth, the internal one of which is very conspicuous.

# OBSERVATIONS ON THE OVIPOSITION OF THE HOUSE-FLY, *MUSCA DOMESTICA*, L., IN PANAMA.*

By L. H. Dunn,

*Entomologist, Board of Health Laboratory, Ancon, Canal Zone.*

During the past twenty-five years and more the house-fly, *Musca domestica*, L., has received much attention from entomologists, medical men, sanitarians and other investigators, and many observations on the life-history, habits, etc., of this fly have been made by individuals in different parts of the world. As a result of the investigations carried out during this period much information has been accumulated regarding the biology of this dangerous nuisance to mankind. However, notwithstanding all these observations and the great amount of knowledge that has been gained, there are a few points that have remained more or less indefinite. One of these is concerning the oviposition of the female fly; the number of eggs deposited during her life-period and the time elapsing between depositions.

According to Newstead,† "The number of eggs laid by a single fly averages from 120 to 140. More than one batch may be laid during the life of the fly, but this question has not been definitely settled."

Howard‡ states, "Each female fly lays on the average 120 eggs, or perhaps more, at a time and may lay several times. Forbes' assistants in Illinois found that eggs from a single fly vary from 120 to 150 in each deposit, and that as many as four deposits may be made, or, say, 600 eggs by a single fly (*in litt.*). One hundred and twenty was the number observed by the writer to be the average number, but Dr. Hewitt has counted as many as 150."

Hewitt§ writes, "From actual counts of eggs in the ovaries of dissected flies and of batches which have been deposited, I found the number varied from 100 to 150, the usual number being 120. This number is confirmed by other observers. During its lifetime as many as four batches of eggs may be laid, as shown by actual observations, by the same fly, and a careful study of the ovaries of a large number of female flies has led me to believe that five or even six batches of eggs may be deposited."

Bishopp, Dove and Parman|| remark, "Dr. A. Griffith, reporting on experiments conducted by him in England, says: 'After ten days the mother fly can lay a new

* These observations were carried out in 1918, but owing to the writer entering the military service and leaving the Isthmus this article was not prepared for publication until his recent return to the Isthmus.

† Newstead, Robert, "On the Habits, Life-cycle and Breeding Places of the Common House-fly (*Musca domestica*, Linn.)."—Annals of Tropical Medicine and Parasitology, i, p. 513, Feb. 1908.

‡ Howard, L. O., "The House Fly, Disease Carrier," p. 18, 1911. Fred A. Stokes Co., New York.

§ Hewitt, C. Gordon, "The House-Fly," p. 100, 1914. The University Press, ~~Manchester,~~ /Cam England.

|| Bishopp, F. C., Dove, W. E., and Parman, D. C. "Notes on Certain Points of Economic Importance in the Biology of the House Fly."—Journal of Economic Entomology, viii, 1, p. 60, Feb. 1915.

batch of eggs, which process it repeats at intervals of ten to fourteen days, till four batches have been laid, when it dies.' Our observations indicate that in Texas fewer batches of eggs, the usual number being two, are deposited and that depositions take place at shorter intervals—about eight days."

Howard and Hutchison* state, "The number of eggs laid by an individual fly at one time undoubtedly is large, probably averaging about 120, and as a single female will lay at least two and possibly four such batches, the enormous numbers in which the insects occur are thus plainly accounted for . . . ."

In 1918, while engaged in carrying on some experiments with the house-fly in the Canal Zone, the writer conducted a series of observations on the oviposition habits in order to obtain more definite information on this phase of the biology of *M. domestica* in the American tropics. The oviposition by individual flies was found to be so much greater than has been supposed heretofore, that the results are deemed worthy of report.

At the beginning of our observations groups of flies confined together in large cages were used, but this method was soon found to be unsatisfactory and consequently discarded. It became early apparent that the only accurate data obtainable by this method was the length of the pre-oviposition period of the first females in the group that oviposited. After the first batch of eggs was deposited it was quite impossible to determine with any degree of accuracy the origin of the following batches, whether but a few females were depositing at frequent intervals or a greater number at longer intervals. Thus becoming convinced of the fact that the data obtained by using groups of flies would consist more of assumed conclusions than of definite and dependable facts, it was decided to use isolated pairs of flies in making the observations.

After experimenting with several kinds of small cages and glass jars, none of which proved satisfactory, Dietz lantern globes, as used in former mosquito-breeding work, were tried and found to be very suitable. The technique of conducting the experiments was as follows :—Fly larvae were obtained from three sources, the city dump at Panama, a compost pit at Corozal, about two miles distant from Panama, and a laboratory strain that had been reared through several generations, thus giving what would apparently be three different strains. After being collected the larvae were placed in fresh horse manure and allowed to remain until pupation, when they were removed and placed singly in test-tubes, which were then stoppered with tight cotton plugs.

The pupae were closely observed, and as soon as the adults appeared they were separated in pairs and transferred to the lantern globes, one pair to a globe. Each globe had its upper, or smaller, end covered with a piece of cotton gauze, held in place with strips of adhesive tape. A circular ring of thin cardboard placed within each globe at its largest part afforded a resting place for the flies. Each globe was placed, large end downward, in a shallow Petri dish of sufficient diameter to allow the bottom of the globe to set in it without much space being left.

Milk and horse manure were used throughout the observations, the former as food for the flies and the latter as material in which to deposit their eggs. The choosing of these two substances was due to the fact that milk is not only strongly attractive to flies, but also contains nearly all of the necessary food elements, and manure, when available under natural conditions, usually seems to be the favourite nidus in which to deposit their eggs.

Considerable care was taken in order to avoid using manure that was already infested. It was collected fresh each morning at the corral, usually being taken

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* Howard, L. O., and Hutchison, R. H. "The House Fly." U.S. Dept. of Agric., Farmers' Bull. 679, Aug. 1917, p. 6.

within a few minutes after dropping, and very often being still warm when brought to the laboratory. It was always collected in a tin can with a closely fitting cover. After reaching the laboratory the cover of the can was partly removed and it was sterilized in an autoclave with steam at 15 lb. pressure for twenty minutes. When removed from the autoclave at the end of this time the cover was again tightly replaced and the manure was left until the following morning before being used.

When ready for use each piece was carefully inspected for eggs before being placed in the globe with the flies. If any were found—which happened but three times during the observations—the manure was discarded and a second lot used, although the eggs found were cooked by the steaming. As a further preventive against counting eggs that might have been overlooked in the search, all eggs after being counted were allowed to hatch as an extra precaution. Eggs that had been through the autoclave were of course rendered non-viable and would not hatch.

When supplying material to a pair of flies a piece of manure about the size of a walnut, after being slightly broken open to provide crevices in which the eggs might be deposited, was placed in a small stender dish, $1\frac{1}{2}$ in. in diameter and 1 in. in height. After depositing a few drops of milk in the centre of the Petri dish the stender dish containing the manure was then placed in the Petri dish on the small pool of milk. This had the effect of pressing the milk out to the edge of the bottom of the stender dish, where it was deposited in a narrow ring, being of such small quantity that it was practically held in place by capillary attraction.

The principal merits of applying the milk in this manner was that it eliminated the use of a second container within the globe and left ample space for the flies to move about on the Petri dish between the stender dish and the edge of the globe. Furthermore, the ring of milk being so small and situated as it was they could feed on it but could not fall into it and become wet and bedraggled, which would have hastened their death. It is believed that the greater part of the success in preventing early mortality among the flies, and in securing the repeated depositions and large numbers of eggs, was due to the use of lantern globes for breeding-jars in place of wire cages and in the manner of administering the milk and manure.

The globes containing the flies were arranged near a window in such a way that some of them were exposed to the bright sunlight practically all of each day, others during part of each day only and the remainder in the shade at all times and receiving no sunlight. However, no appreciable difference was observed in the number or frequency of depositions or the number of eggs deposited between those exposed to the sunlight and those that were in the shade, although a slight difference of temperature and humidity possibly existed at times. It was noticed that the milk and manure dried up more quickly in the globes that were exposed to the sunlight, which was to be expected.

Throughout these observations the globes were examined three times daily. These examinations occurred between 8 to 12 a.m., 2 to 6 p.m., and 8 to 12 p.m. Thus the only period during which no check was made was from midnight to 8 a.m.

At each examination the globe was lifted slightly from the Petri dish and a piece of cardboard slipped underneath to prevent the flies from escaping. The stender dish containing the manure was removed and the Petri dish washed clean of all milk and dried well. Fresh milk was dropped in the centre again and a clean stender dish containing fresh manure was placed in the milk. After removing the cardboard from the bottom of the globe the latter was then replaced on the Petri dish. The manure taken from each globe was then carefully inspected, being teased into small shreds, and all eggs found were removed and counted with the aid of a hand lens and a blunt dissecting needle, the latter being used to separate them. After being counted they were placed in a second piece of manure until the larvae emerged as a test for fertility.

A total of 42 pairs of flies were observed, and the results obtained are shown in the following table :—

Females Nos. 3 and 30 were killed on the thirty-fourth day. This was due to the writer leaving for the United States on the day following.

The 168 eggs (†) deposited by female No. 21 on the fourth day consisted of two batches, 95 in the a.m. and 73 in the p.m.

Only two batches of eggs of the entire number deposited were found to be non-viable. These were undoubtedly infertile eggs, and not some that had passed through the autoclave and not discovered in the manure before being placed in the jar, as they were white and of normal size, while the three batches of eggs previously mentioned as being autoclaved were noticed to be apparently enlarged and with a yellowish tinge, which was possibly caused by taking up some colour from the steaming manure. Moreover, these two batches were deposited by the same female on two successive days. These two batches are not included in the tables on oviposition or in the general count.

As previously mentioned, the flies used for these observations were bred from three different strains, but no appreciable difference was noted in any way.

The results obtained by Pomeroy while working with isolated pairs, as given by Hutchison, differed greatly from those of the series carried out by myself. He succeeded in getting but 7 females out of 30 to oviposit while confined as isolated pairs, and but 2 of the 7 deposited a second batch of eggs. The maximum number of eggs deposited by any one female out of the 7 that oviposited was 110. In writing of Pomeroy's observations, Hutchison* states, " The fact that only 7 out of some 30 tests gave any positive results points to the difficulties in obtaining significant data from experiments performed under artificial conditions."

Judging from the literature at hand, it is quite probable that the observations on the oviposition of *M. domestica* as shown in the foregoing pages are the most successful and accurate that have as yet been made. More especially is this evident owing to the observations having been made while working with isolated pairs of flies, which in my estimation is the only satisfactory method of obtaining accurate results in oviposition studies.

These observations also show that the time between deposits of eggs may be much shorter than has been heretofore recognised. This was indicated by a number of females depositing large batches of eggs at intervals of approximately 36 hours.

Although no special attempts were made to ascertain the pre-copulation period of each pair, it was noted in several instances, in two of which copulation occurred within 24 hours after emergence. Promptness in supplying food and material in which to deposit eggs after the adults emerge seems to exert considerable influence on the length of this period.

It was noted that after successful copulation once occurred the female remained fertilised throughout her life-period, and all eggs deposited were fertile, with but very few exceptions, without later copulation being necessary.

Temperature and humidity are factors that undoubtedly have a strong influence on the life-history of the house-fly, and it may be safely assumed that the biology of this fly in the tropics differs somewhat from that in temperate regions. However, the dry season in Panama, during which time these observations were carried out, is not so different from the summer months in the southern part of the United States as one would expect.

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* Hutchison, R. H. " Notes on the Pre-oviposition Period of the House-fly, *Musca domestica*, L." U.S. Dept. Agric., Bull. 345, Feb. 1916, p. 8.

| Female of pair No. | EGGS DEPOSITED—DAYS FOLLOWING EMERGENCE OF FEMALES. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Totals. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | |
| 1 = | | | A.M. 55 | | | A.M. 97 | | A.M. 119 | | A.M. 159 | | A.M. 107 | P.M. 114 | P.M. 116 | P.M. 123 | | P.M. 122 | | A.M. 116 | P.M. 102 | | A.M. 127 | P.M. 102 | | P.M. 107 | A.M. Dead | | | | | | | | | 1,566 |
| 2 = | | | | | A.M. 134 | | A.M. 139 | | | A.M. Dead | | | | | | | | | | | | | | | | | | | | | | | | | 273 |
| 3 = | | | | P.M. 139 | | P.M. 142 | | A.M. 151 | | A.M. 136 | P.M. 132 | | P.M. 112 | | P.M. 142 | | A.M. 140 | A.M. 100 | | P.M. 74 | | | | P.M. 88 | | A.M. 95 | | P.M. 48 | | P.M. 43 | | P.M. 38 | P.M. 22 | P.M. Dead | 1,602 |
| 4 = | | | A.M. 126 | | | P.M. Dead | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 126 |
| 5 = | | | P.M. 128 | | A.M. 134 | | P.M. 130 | P.M. 121 | | | A.M. 131 | P.M. 53 | | A.M. 65 | A.M. Dead | | | | | | | | | | | | | | | | | | | | 762 |
| 6 = | | | | | A.M. 111 | | P.M. 103 | | A.M. Dead | | | | | | | | | | | | | | | | | | | | | | | | | | 214 |
| 7 = | | | | A.M. 124 | P.M. 116 | P.M. 127 | | P.M. 115 | | A.M. 108 | P.M. 101 | | A.M. 95 | P.M. 69 | | A.M. 60 | P.M. 45 | P.M. 63 | | P.M. 33 | | P.M. 37 | | P.M. 26 | A.M. Dead | | | | | | | | | | 1,119 |
| 8 = | | | P.M. 133 | | A.M. 142 | P.M. 140 | | A.M. 144 | P.M. 137 | P.M. 133 | | | A.M. 139 | A.M. 140 | | A.M. 136 | P.M. 118 | | A.M. 110 | | | A.M. Dead | | | | | | | | | | | | | 1,472 |
| 9 = | | | A.M. 141 | P.M. 134 | P.M. 143 | | A.M. 110 | P.M. 142 | P.M. 127 | | A.M. 133 | | A.M. 141 | A.M. 147 | | P.M. 106 | P.M. 137 | | P.M. 129 | | A.M. 124 | | P.M. 128 | | A.M. 93 | P.M. 114 | | P.M. Dead | | | | | | | 2,049 |
| 10 = | | | | A.M. 142 | | A.M. 131 | P.M. 134 | | A.M. 127 | | P.M. 106 | | P.M. 130 | | | P.M. 79 | | | A.M. 126 | A.M. Dead | | | | | | | | | | | | | | | 975 |
| 11 = | | | A.M. 138 | | P.M. 131 | | A.M. 147 | | A.M. 115 | | P.M. 128 | | P.M. 122 | | A.M. Dead | | | | | | | | | | | | | | | | | | | | 781 |
| 12 = | | | | P.M. 147 | | | A.M. 151 | | P.M. 147 | | | P.M. 143 | | | P.M. 72 | A.M. Dead | | | | | | | | | | | | | | | | | | | 660 |
| 13 = | | | A.M. 65 | P.M. 81 | | | A.M. 70 | A.M. Dead | | | | | | | | | | | | | | | | | | | | | | | | | | | 216 |
| 14 = | | | A.M. 130 | | P.M. 121 | | A.M. 113 | P.M. 95 | | A.M. 110 | P.M. 113 | P.M. 91 | | | P.M. 112 | P.M. 61 | | P.M. 103 | | P.M. 83 | P.M. 84 | | P.M. 85 | | P.M. 61 | | P.M. 35 | A.M. 18 | P.M. 32 | | A.M. Dead | | | | 1,447 |
| 15 = | | | A.M. 126 | | A.M. 121 | | A.M. 112 | A.M. 117 | | | P.M. 102 | P.M. 89 | | P.M. 56 | A.M. Dead | | | | | | | | | | | | | | | | | | | | 723 |
| 16 = | | | | | | | A.M. Dead | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 |
| 17 = | | P.M. 130 | | P.M. 120 | | | | A.M. 121 | | | P.M. 153 | | | | A.M. 72 | P.M. 92 | | P.M. 83 | | | A.M. 91 | A.M. Dead | | | | | | | | | | | | | 862 |
| 18 = | | | | | | | | | | | | P.M. Dead | | | | | | | | | | | | | | | | | | | | | | | 0 |
| 19 = | | A.M. 128 | | A.M. 124 | P.M. 123 | | | A.M. 128 | | A.M. 106 | | | P.M. Dead | | | | | | | | | | | | | | | | | | | | | | 609 |
| 20 = | | | P.M. 54 | A.M. 55 | P.M. 103 | | A.M. 119 | P.M. 123 | | | P.M. 127 | | P.M. 104 | P.M. 118 | | P.M. 105 | | A.M. 114 | P.M. 96 | | P.M. 119 | | A.M. 94 | | A.M. 104 | | A.M. 91 | | | P.M. Dead | | | | | 1,526 |
| 21 = | | | A.M. 102 | † 168 | | | P.M. 107 | | A.M. Dead | | | | | | | | | | | | | | | | | | | | | | | | | | 377 |
| 22 = | | A.M. 126 | | | A.M. 123 | A.M. 121 | | A.M. 122 | P.M. 17 | P.M. Dead | | | | | | | | | | | | | | | | | | | | | | | | | 509 |
| 23 = | | | A.M. 107 | P.M. 99 | | A.M. 104 | P.M. 26 | A.M. 101 | A.M. 123 | | P.M. 109 | | A.M. 114 | A.M. 92 | P.M. 92 | | A.M. 93 | A.M. 81 | | A.M. 60 | A.M. Dead | | | | | | | | | | | | | | 1,201 |
| 24 = | | | P.M. 111 | P.M. 112 | | A.M. 111 | P.M. 106 | | A.M. 109 | A.M. 81 | | P.M. 107 | | A.M. 105 | P.M. 73 | | A.M. 98 | | A.M. 82 | P.M. Dead | | | | | | | | | | | | | | | 1,095 |
| 25 = | | | P.M. 114 | | A.M. 109 | P.M. 117 | P.M. 112 | | P.M. 97 | | P.M. 115 | | A.M. 84 | A.M. Dead | | | | | | | | | | | | | | | | | | | | | 748 |
| 26 = | | | P.M. 115 | | A.M. 124 | P.M. 130 | | P.M. 130 | | A.M. 40 | A.M. 89 | P.M. 124 | | | A.M. 117 | | A.M. 118 | | A.M. 116 | P.M. 120 | | P.M. 98 | | A.M. 84 | | P.M. Dead | | | | | | | | | 1,405 |
| 27 = | | | P.M. 94 | | | P.M. 89 | P.M. 75 | | | | | A.M. 133 | | A.M. 80 | P.M. 92 | | P.M. 84 | | A.M. 82 | | P.M. 69 | | A.M. 61 | | A.M. 60 | A.M. Dead | | | | | | | | | 919 |
| 28 = | | P.M. 115 | | P.M. 106 | | A.M. 119 | P.M. 114 | | P.M. 117 | | P.M. 114 | P.M. 121 | | A.M. 114 | P.M. 123 | | P.M. 108 | | A.M. 110 | P.M. 105 | | P.M. 108 | | A.M. 83 | P.M. 111 | P.M. Dead | | | | | | | | | 1,668 |
| 29 = | | | A.M. 85 | A.M. 101 | | P.M. 96 | | A.M. 105 | | P.M. 101 | | A.M. 76 | P.M. 104 | | P.M. 101 | P.M. 97 | | P.M. 95 | | A.M. 97 | | P.M. 65 | | P.M. 78 | | A.M. 71 | | P.M. 53 | A.M. Dead | | | | | | 1,325 |
| 30 = | | P.M. 113 | | P.M. 122 | P.M. 61 | A.M. 61 | P.M. 123 | | A.M. 128 | | P.M. 109 | P.M. 117 | P.M. 126 | | A.M. 126 | P.M. 124 | P.M. 124 | | P.M. 124 | P.M. 127 | | A.M. 110 | A.M. 124 | P.M. 116 | | P.M. 118 | | A.M. 120 | | A.M. 105 | P.M. 109 | | | A.M. Dead | 2,387 |
| 31 = | | | P.M. 117 | | P.M. 108 | | A.M. 132 | P.M. 107 | | A.M. Dead | | | | | | | | | | | | | | | | | | | | | | | | | 464 |
| 32 = | | | P.M. 117 | P.M. 126 | | P.M. 140 | | | P.M. 112 | | | A.M. 138 | P.M. 95 | | P.M. 114 | | A.M. 121 | P.M. 119 | | P.M. 61 | P.M. 68 | | P.M. 121 | | P.M. 81 | | | | | | A.M. Dead | | | | 1,413 |
| 33 = | | | P.M. 116 | | A.M. 133 | | A.M. 15 | A.M. 112 | | | P.M. 108 | | A.M. 48 | A.M. 104 | | A.M. 115 | A.M. 115 | | A.M. 101 | | A.M. 96 | | A.M. 88 | | P.M. 25 | P.M. Dead | | | | | | | | | 1,176 |
| 34 = | | | P.M. 124 | | | A.M. 134 | P.M. 119 | | A.M. 127 | P.M. 122 | | P.M. 44 | | A.M. 68 | P.M. 98 | | P.M. Dead | | | | | | | | | | | | | | | | | | 836 |
| 35 = | | | P.M. 102 | | A.M. 122 | P.M. 117 | | A.M. 107 | P.M. 122 | | P.M. 120 | | P.M. 113 | P.M. 113 | P.M. 120 | | P.M. 114 | | P.M. 119 | | P.M. 118 | | A.M. 122 | | A.M. 116 | | A.M. 111 | | A.M. 106 | A.M. Dead | | | | | 1,842 |
| 36 = | | | A.M. 118 | P.M. 120 | | P.M. 117 | | A.M. 123 | P.M. 114 | | P.M. 119 | | A.M. 112 | P.M. 107 | | A.M. 119 | P.M. 123 | | P.M. 116 | | A.M. 120 | P.M. 111 | | P.M. 101 | | A.M. Dead | | | | | | | | | 1,620 |
| 37 = | | | P.M. 105 | P.M. 110 | | P.M. 124 | | A.M. 111 | P.M. 71 | | P.M. 92 | | A.M. 81 | | P.M. 81 | | A.M. 51 | | A.M. 78 | P.M. 67 | | P.M. 76 | | P.M. 29 | P.M. Dead | | | | | | | | | | 1,078 |
| 38 = | | | P.M. 115 | P.M. 122 | | P.M. 128 | | A.M. 112 | A.M. 122 | | A.M. 115 | P.M. 112 | | P.M. 115 | | A.M. 117 | | A.M. 104 | | A.M. 42 | | | | A.M. Dead | | | | | | | | | | | 1,204 |
| 39 = | | | P.M. 39 | A.M. Dead | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 39 |
| 40 = | | | P.M. 102 | | A.M. 128 | | A.M. 135 | P.M. 123 | P.M. Dead | | | | | | | | | | | | | | | | | | | | | | | | | | 488 |
| 41 = | | | P.M. 127 | P.M. 129 | | | P.M. 30 | P.M. 154 | | P.M. 116 | | | A.M. 110 | P.M. 108 | | P.M. 119 | | P.M. 109 | | P.M. 111 | | P.M. 105 | | P.M. 24 | | | | | | | A.M. Dead | | | | 1,242 |
| 42 = | | | P.M. 101 | | | A.M. 127 | | A.M. 120 | P.M. 135 | | P.M. 123 | | A.M. 131 | P.M. 123 | | A.M. 116 | P.M. 101 | | A.M. 117 | P.M. 99 | | A.M. 101 | A.M. 111 | | A.M. 113 | P.M. 49 | A.M. 18 | A.M. 79 | | P.M. 83 | P.M. Dead | | | | 1,847 |

TOTAL .. .. 41,863

The Monthly Meteorological Report of the Panama Canal gives the temperature and humidity at Balboa Heights, near Ancon, for the three months during which these observations were being carried out as follows :—

| 1918. | Average Maximum Temperature (deg. Fahr.) | Average Minimum Temperature (deg. Fahr.) | Average Mean Temperature (deg. Fahr.) | Mean Relative Humidity (per cent.) |
|---|---|---|---|---|
| January .. .. | 86·0 | 70·8 | 78·5 | 81·4 |
| February .. .. | 87·9 | 71·4 | 79·7 | 76·0 |
| March .. .. | 88·3 | 70·4 | 79·4 | 79·0 |

These observations on the house-fly in Panama may be briefly summarised as follows :—

Copulation may occur within 24 hours after emergence.

One successful copulation seems to be sufficient to fertilise the female for her life-period.

Oviposition may take place as early as two and a quarter days after emergence.

As many as 159 eggs may be deposited in one batch.

Large batches are sometimes deposited at intervals of but 36 hours.

One female may deposit as many as 21 batches, or a total of 2,387 eggs, in 31 days after emergence.

# A NEW PHYTOPHAGOUS CHALCID ATTACKING BAMBOO.

By James Waterston, B.D., D.Sc.

In a recent and very useful summary of our present knowledge of phytophagous Chalcids (Proc. Ent. Soc. Wash., xxiv, no. 2, Feb. 1922) Mr. A. B. Gahan describes (p. 55, pl. vii, fig. 2, 2*a*) a new Eurytomid, *Harmolita phyllostachitis* (bred from *Phyllostachys bambusoides* in California), which is apparently the only Chalcid hitherto reared from such host-plants. I owe to the Director of the Imperial Bureau of Entomology the opportunity of bringing forward a second *Harmolita* with the same general habit, but from a widely separated region.

Unfortunately in the Oriental species now described the precise point of attack on the host-plant is not mentioned by the collector. The Californian species oviposits through the sheath at the node, and the insect's development takes place immediately above this point.

While *H. phyllostachitis*, Gahan, and *H. aequidens*, sp. n., are abundantly distinct in colour and morphology, they resemble one another in their slender build, and differ from *Harmolita* as restricted by Phillips & Emery (Proc. U.S. Nat. Mus., lv, p. 435, 1916) in the umbilicate punctuation of the thorax. It is possible, therefore, that they represent a group to which a higher status may yet have to be given. Both species, however, run easily and directly down to *Harmolita* in the present scheme of classification, and, like Mr. Gahan (*loc. cit.*, p. 55), I think it better in the meantime not to define a new genus on characters whose value, after all, may only be comparative.

**Harmolita aequidens,** sp. n.

♀.—General ground-colour pale transparent brown, in parts extensively infuscated or black. Head with the following regions darkened: lower genae, mid-occiput, mid-vertex and antennal fossae to toruli, and thence in a broadening triangle to mouth-corners. Antennae black, apex of pedicel and mid-longitudinal streak on scape obscurely paler. Trophi pale, apices of mandibles darkened. Thoracic surface dorsally blackish-brown; sides of pronotum broadly, axillae obscurely, and, in some specimens, an indefinite spot on each side of the mid-sulcus of the propodeon, pale. Ventrally the infuscated areas are the sides of the propleurae, an apical (distal) spot and posterior edge of prosternum, and the fused ventral area of prepectus and metasternum. Fore-wings faintly brown-tinted, veins brown, with a yellowish-brown streak running obliquely backwards from the uprise of the submarginal and meeting a similar streak parallel to the hind margin along the basal half. Legs pale, hind femora slightly darker dorsally, hind tibiae extensively but faintly infuscated, paler at base and apex. Abdomen dorsally shining black, venter and overlaps of tergites pale. Spiracles on tergite 6 (8) outlined in black.

Head (fig. 2, *a*) wider (29 : 23) than deep. Eyes occupying nearly half (11 : 23) the depth. Frons at widest two-thirds the breadth of the head. Toruli set high up. Seen from in front the distance from the clypeal edge to the toruli is over twice (16 : 7) that from the toruli to the level of the posterior ocelli; clypeal edge with a flat triangular median tooth or lobe. Clypeus medianly smooth above the tooth; an ill-defined frontal keel runs upwards to and between the toruli. Antennal fossa continued on vertex, where it takes in the anterior ocellus. Ocellar triangle very flat and obtuse, lateral ocelli about as far from one another as from the orbits. General surface

(fig. 2, *a*) finely raised reticulate, with numerous large, often irregular and indistinct, and always shallow umbilicate punctures, which are weaker and fewer on occiput. Genae merely reticulate, faintly shining.

Antennae (fig. 1, *a*) about 3·2 mm. long, about half as long as the whole body, 11-jointed, slender; funicle narrower than pedicel; club hardly enlarged; ring joint well developed, longer (6 : 5) than wide. Proportions of joints: scape, 190 : 40; pedicel, 68 : 34; ring joint, 24 : 20; funicle i, 145 : 24 proximally, 145 : 21 distally; ii, 140 : 21; iii, 140 : 21; iv and v, 130 : 21; vi, 120 : 21; and vii (together with the club), 90 each, with breadth at suture 24 and elsewhere 27.

Labrum (fig. 2, *c*); mandibles (fig. 2, *b*) bidentate at apex, with a rounded edge above the second tooth. Stipes with 6–7 bristles; maxillary palpi, 6, 9, 7, 17, first joint with one long bristle, second joint bare, with one short hyaline sensorium in pit, third joint with 1–2 bristles, fourth with about six bristles, one short fine terminal spine and another stout hyaline truncated one not quite one-third the length of the supporting joint.

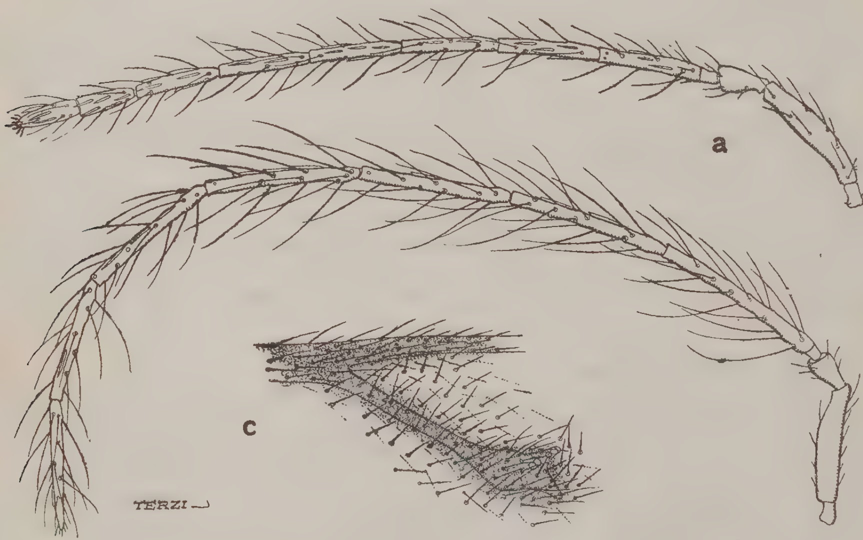


Fig. 1. *Harmolita aequidens*, Waterston; *a*, antenna of ♀; *b*, antenna of ♂; *c*, radius of fore-wing, ♀.

Thorax flat (for shape and sculpturation see fig. 2, *d*). Pronotum very large, distinctly separated from mesonotum at sides and one-third longer than mesoscutum along the mid-line. Parapsidal furrows deep and crenulate. Scutellum nearly as long as pronotum (9 : 10). Median sulcus of propodeon deep. Prepectora and sternopleural surfaces without any large shallow punctures, more or less smooth and shining. Surface of the mesepimeron, especially on the upper half, rather coarsely striate. Posteriorly the sternum and the mesopleurae on the postero-ventral two-thirds are pilose, each hair rising from a small puncture.

Fore-wings (22 : 7), length 4·4 mm., breadth 1·4 mm.; submarginal, marginal, radius, postmarginal in ratio 45 : 16 : 8 : 11. The radius (fig. 1, *c*) has a well-developed narrow club. Whole alar surface with a rather long and dense pile and a short bare streak below the submarginal at its uprise; another shorter less definite one below the marginal, just beyond the uprise. Immediately opposite this, on the hind edge

with only one intervening row of bristles, is a small bare spot, while the radix for a short distance along the posterior edge is also bare. There are about 20 stout bristles on the submarginal. Hind-wings (5 : 1), length 3 mm., breadth 0·6 mm., neuration strongly angled, proximal piece to distal in ratio 5 : 3; submarginal cell bare on proximal half; surface generally pilose, except narrowly on radix posteriorly along the edge to about one-third.

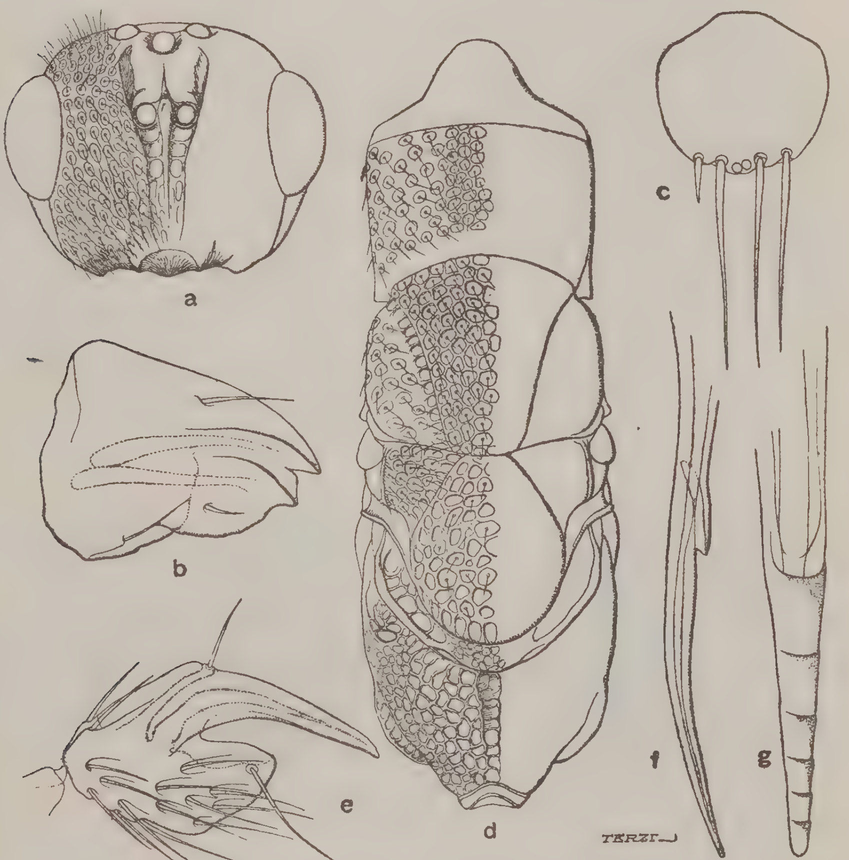


Fig. 2. *Harmolita aequidens*, Waterston, ♀; *a*, head; *b*, mandible; *c*, labrum; *d*, thorax and propodeon; *e*, claw of hind tarsus; *f*, *g*, tip of ovipositor.

Fore-legs: coxa (20 : 9) elongate, pyriform, much broader (3 : 2) and not much shorter (5 : 7) than the femur (14 : 3); the latter just longer (12 : 11) than the tibia (6 : 1), which bears subapically a transverse row of six spinose bristles, and one on dorsal edge anteriorly above the insertion of the first tarsal joint; the tarsus is subequal to the femur, comb of the first joint with 20–22 spines. Mid-legs: coxa (4 : 3) two-fifths the femur (14 : 3), which is four-fifths of the tibia (about 12 : 1); the latter, as in the fore-legs, subequal to the tarsus; tibial spur very short, four-fifteenths of the first tarsal joint measured ventrally. Hind-legs: coxa (3 : 2) rather more than half (7 : 12) the femur (7 : 2), the latter being about two-thirds the tibia (10 : 1); comb

of the latter with 16–17 spines, longer spur one-fourth the first tarsal joint; externally the coxa is rough (coarsely raised reticulate) on upper half and bears a median longitudinal row of 14–15 long bristles; inner (posterior) surface bristly on apical two-thirds; on the femur, besides a number of dorsal or subdorsal bristles, there are on each aspect 6–7 longer bristles and posteriorly about 12 near the ventral edge.

Proportions of tarsal joints :—

| Tarsal joints .. .. .. | i | ii | iii | iv | v |
|---|---|---|---|---|---|
| Fore-legs .. .. .. | 26 | 16 | 12 | 8 | 18 |
| Mid and hind-legs .. .. | 43 | 23–24 | 16 | 10 | 18–20 |

Abdomen considerably compressed, smooth and shining; though the tergites, where medianly more heavily chitinised and infuscated, have a distinct internal structure of hexagonal cells, the superficial gloss is not interfered with; petiole about one-fourth the length of hind coxa. Ovipositor very slightly projecting. Mid-point of last sternite apically not reaching half-way between the apex of the petiole and the tip of the abdomen. The proportions of the segments vary according to degree of the extension of the abdomen. Measured along the mid-line tergite i (iii) is longest, but only just exceeding T. iv (vi), which, however, *appears* to be longest, as it is straight and not on the curve; T. ii (iv) is shortest, hardly exceeding one-third of T. i; T. iii (v) is one-half longer than T. ii; T. v (vii) and T. vi (viii) are subequal and about one-third longer than T. iii. The spiracles on T. vi are small and practically circular. On each side of the mid-line the tergites bear the following short hairs, i and ii, 3; iii, 5–6 (in a single row); iv, 7–9 (two irregular rows); v, about 20 (three rows); vi, about 30 (four rows). Ovipositor sheath bare, except for a number of fine short hairs round the apical edge; ovipositor tip (fig. 2, *f*, *g*) with six completely transverse teeth. Venter weakly chitinised, smooth, bare.

Length, 6·4–7 mm.; alar expanse, 9–10 mm.

♂.—Similar to the ♀ in colour, but more extensively pale on the head, which is only slightly darkened on the mid-occiput, round the ocelli, and narrowly on the subtorular keel. Legs entirely pale and clear.

Antennae (fig. 1, *b*) slender, without club, three-fourths the length of the body. Proportions: scape, 170; pedicel, 60; ring joint, 18; funicle i and ii, 255; iii, 240; iv, 220; v, 210; vi, 185; vii, 190; the breadth of scape in the same scale is 50, pedicel 40, ring joint 20, funicle i, 34 (base), 24 distally and thereafter about 21.

Abdomen: petiole long, equal to the hind coxa and trochanter together, dorsally rugulose; tergites i and vi longest and subequal, nearly twice as long as ii or v, which are also subequal; iii and iv about one-fourth shorter than i.

Length, about 5–7 mm.; alar expanse about 8 mm.

*Type* ♀ in British Museum, one of a series of 10 ♀, 3 ♂, reared from larvae tunnelling in bamboo stem.

FEDERATED MALAY STATES: Kuala Lumpur, ix.1921 (*G. H. Corbett*).

# A NEW EAST AFRICAN TSETSE-FLY (GENUS *GLOSSINA*, WIED.), WHICH APPARENTLY DISSEMINATES SLEEPING SICKNESS.

By Major E. E. Austen, D.S.O.

Although within the last few years—chiefly owing to the diagnostic ability and brilliant technical skill of Professor Robert Newstead, F.R.S.—several additions have been made to the list of recognised species of *Glossina*, the numerical total of which now stands at nineteen, the *Glossina morsitans* Group has not received a single accession. Peculiar interest therefore attaches to the discovery of the species described below, not only by reason of its apparent pathogenic importance,* but also on account of its systematic position within the genus. The new species in question, of which, through the courtesy of the Imperial Bureau of Entomology, the types and paratypes, in addition to a series of other examples, are in the British Museum (Natural History), may be characterised as follows :—

**Glossina swynnertoni,** sp. n. (figs. 1, 2, 3).

♂♀.—Length, ♂ (six specimens) 7·6 to 8·6 mm., ♀ (six specimens) 8·6 to 9·5 mm., width of head, ♂ 2·5 to just over 2·5 mm., ♀ 2·5 to 2·6 mm. ; width of front at vertex, ♂ 0·6 mm., ♀ just under 1 mm. ; length of wing, ♂ 7·8 to 8 mm., ♀ 8·6 to 9 mm.

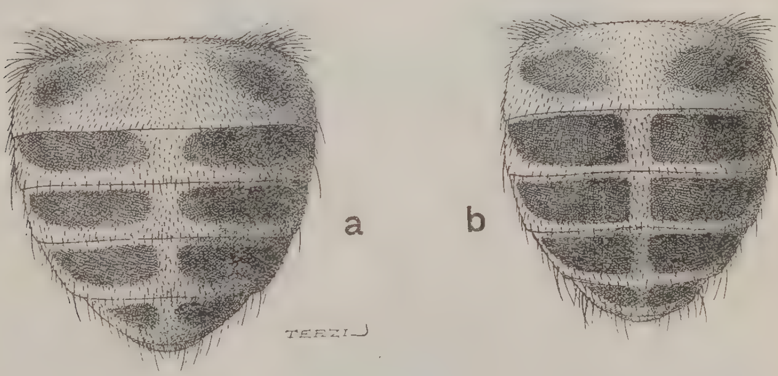


Fig. 1. Abdomens of (a) *Glossina morsitans*, Westw., ♂, and (b) *G. swynnertoni*, Austen, ♂, dorsal view, × 12 ; first (basal) tergite not shown in either case.

*A member of the* Glossina morsitans Group *and closely allied to* G. morsitans, *Westw., from normal specimens of which it is at once distinguishable in the case of both sexes by its much darker coloration ; by the ground-colour of the dorsum of the abdomen being drab,† light drab or drab-grey (occasionally, especially in centre of second tergite, cinnamon-buff or greyish-cinnamon-buff) instead of buff-yellow or ochraceous-buff ; by the paler area in the centre of the second abdominal tergite being much less conspicuous and much*

* *Cf.* Mr. C. F. M. Swynnerton's statements, *infra*, p. 337.

† For names and illustrations of colours mentioned in the present paper see Ridgway, " Color Standards and Color Nomenclature." (Washington, D.C. Published by the Author, 1912.)

*more restricted in extent; and by the interrupted, transverse, abdominal bands being very dark, more regular in shape, approaching closer to the hind margin of the segment in each case, and having their inner ends close together, sharply defined and terminating squarely (instead of more or less tapered-off or even obsolescent), so that the pale median interspace on the third to the fifth tergites inclusive forms a narrow, clean-cut, longitudinal stripe, which is of uniform width on the third and fourth tergites, and slightly narrower on the fifth* (*cp*. a and b, fig. 1); *distinguishable also in the male sex by the different shape, heavier chitinisation and much darker coloration of the superior claspers, by the greater size and much greater prominence of the process or tooth* ("median process," "submedian process" or "submedian prominence" of Newstead) *on the distal margin of each of the latter, and by the strikingly different shape of the median lobes* (*cf*. fig. 2).

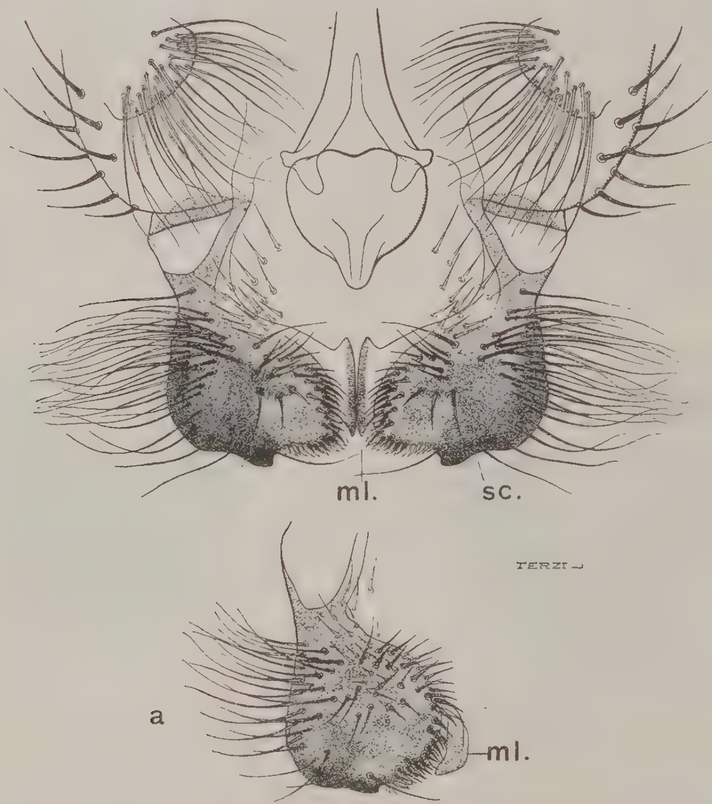


Fig. 2. Male genital armature of *Glossina swynnertoni*, Austen, ventral view; sc., superior clasper; ml., median lobe; a, right superior clasper of *G. morsitans*, Westw., for comparison; ml., median lobe.

*Head* in both sexes similar to that of *G. morsitans*, Westw., the dark brown blotch on upper part of lower half of each parafrontal (side of front) in ♀ usually strongly marked; *antennae* with distal extremity of arista in both sexes usually slightly less attenuate than in *G. morsitans*.

*Thorax* much as in *G. morsitans*, though dark markings on dorsum, especially in ♀, are often more distinct; apical scutellar bristles in ♀, as in same sex of *G. morsitans*, extremely short, reduced to mere stumps.

*Abdomen* (*cf.* fig. 1, b): dark blotches on second tergite in both sexes more transversely ovate than corresponding blotches in case of *G. morsitans*, and their inner extremities as a rule much more closely approximate; interrupted transverse bands on following three tergites black, blackish-brown or olivaceous-black, clearly defined in both sexes, occupying approximately the anterior three-fourths of the segment in each case, and having the posterior margin of the inner half of each half-band parallel to that of its tergite; ground-colour of sixth and seventh tergites drab-grey in both sexes, anterior half or three-fifths of sixth tergite occupied by a dark transverse band, which tapers towards each basal angle but does not reach it, while in the middle line it is sometimes only indistinctly interrupted, although strongly emarginate posteriorly; *hectors* of ♂ agreeing in shape with those of *G. morsitans* but much darker (neutral grey, deep neutral grey or dark neutral grey), usually contrasting sharply in colour with base of median triangle separating their distal extremities, whereas in *G. morsitans* the hectors are but slightly darker than corresponding triangle; *hypopygium* of ♂ pinkish-cinnamon, dusky drab or deep brownish-drab, similar in size and appearance to that of *G. morsitans*, though, if anything, slightly larger; *superior claspers* of ♂ with the transverse diameter of the distal portion of their spatulate expansions distinctly greater than in *G. morsitans* (see fig. 2), and with their *median lobes* (ml) in each case terminating distally in a sharp point, instead of having their apices blunt and divergent as in *G. morsitans* (*cf.* figs. 2, 2a).

*Wings, squamae* and *halteres* as in *G. morsitans*.

*Legs* as in *G. morsitans*, except that the local infuscation of the femora is, at least in the case of the ♂, usually more pronounced.

Tanganyika Territory (Mwanza District): type of ♂ and type of ♀, Ididi R. six miles from Kindabu, 15.v.1922 (*P. Tully*); one ♂ paratype, Mwangwhela, 22.v.1922 (*C. F. M. Swynnerton*); four ♂ paratypes, road west of Zagayu, 26.v.1922 (*P. Tully*); three ♀ paratypes, Ngali, 17.v.1922 (*C. F. M. Swynnerton*); one ♀ paratype, between Tomao and Zagayu, 16–18.v.1922 (*P. Tully*); one ♀ paratype, Lukungu, 15.vi.1922 (*C. F. M. Swynnerton*).

In addition to the specimens selected as types and paratypes, and referred to in the foregoing paragraph, Mr. Swynnerton has brought to England several thousand males and females of the new species, collected during May and June of the present year in more than twenty different localities in the Mwanza District. A representative series of examples, selected from this material, has been examined by the writer, and in a number of instances, with the kind assistance of Mr. Swynnerton, the male genitalia have been mounted and studied under the microscope. In no case has there been detected any noteworthy variation from the typical form as described above, and in not a single instance was there any doubt that the specimen under examination was specifically distinct from *Glossina morsitans*, Westw. The diagnostic characters of the new species (printed in italics at the commencement of the above description) seem indeed to be remarkably stable. On the other hand, as is well known, *G. morsitans* often exhibits considerable variation as regards the completeness or otherwise of its abdominal markings, and certain individuals, particularly those belonging to the form *submorsitans*, Newst., sometimes present what may at first sight appear to be a deceptive similarity to *G. swynnertoni* in the shape, depth and completeness of their abdominal bands. In such cases, however, apart from the difference in the ground-colour of the abdomen that is usually noticeable, closer scrutiny will show that the hind margins of the inner halves of the dark half-bands are not so uniformly parallel to those of the respective segments as in the species just described. Finally, any doubt that may still linger can be allayed by means of an examination of the male genitalia.

For the association of the name of Mr. C. F. M. Swynnerton, Game Warden, Tanganyika Territory, with the interesting and important species characterised above no apology is needed. Mr. Swynnerton, whose admirable description of the tsetse-fly investigations carried out by him in Portuguese East Africa some four years ago will be fresh in the memory of readers of this journal,* has kindly supplied the following note on the area in which the new species occurs, and on the impression made on him by the latter in the field.

"A great block of acacia savannah woodland, surrounded by open country, lies in the Usukuma area of the Mwanza District. It extends on the west to a few miles west of the Simiyu R.; on the east to the great Serengeti plain; on the north (in places) to the Speke Gulf, Lake Victoria, to the Ushashi escarpment and, I believe, to a point beyond Ikoma, Nyamatoki; and on the south nearly to Lake Eyasi and the Sibiti River. My specimens of *G. swynnertoni* have been taken between its western border and Mount Ngasamo (north of the Duma R.), and between Nasa, on Lake Victoria, and the foot of the Ushashi escarpment; but the whole block that I have described is infested with tsetse, and, I believe, with this particular species. The insect has also been taken in numbers by fly-boys of mine reporting to Mr. A. M. D. Turnbull on the mainland opposite Ukerewe Island (L. Victoria), and has been sent to me in abundance by Mr. G. G. Griffiths from the Chinyanga fly-belt, a smaller block of acacia woodland south-east of the main one already described.

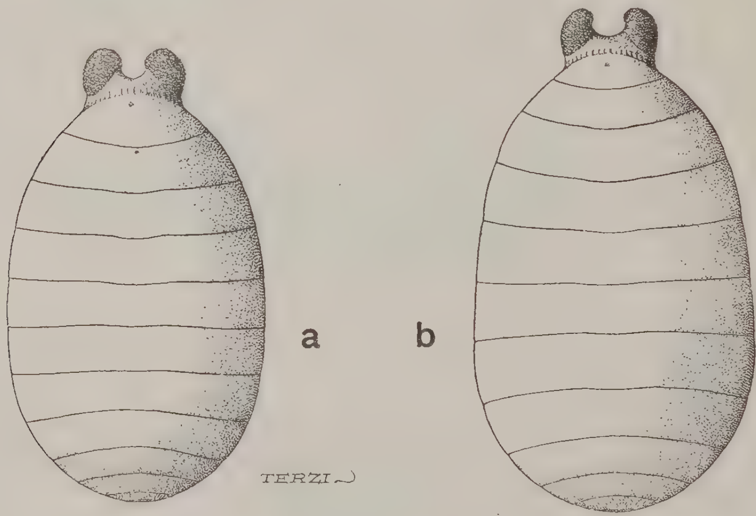


Fig. 3. Puparia of (a) *Glossina morsitans*, Westw., and (b) *G. swynnertoni*, Austen, ventral view. × 12.

"My fly-boys, arriving in Mwanza a few days before myself, were shown specimens of this fly by Dr. G. Maclean and Mr. A. M. D. Turnbull (Medical Officer and Senior Commissioner), and were deceived by its coloration into regarding it as a form of *G. palpalis* (which they knew). They insisted that it was not *G. morsitans*, which they knew well also, having collected this species in various parts of Tanganyika Territory. I was similarly puzzled on arrival, and could think only of *G. longipalpis*

* *Cf.* Swynnerton, C. F. M., "An Examination of the Tsetse Problem in North Mossurise, Portuguese East Africa"—Bull. Ent. Res., London, xi, 4, pp. 315–385, Plates ix–xvii, and Map (March 1921).

which, although I had never met with it, this fly rather resembles, except in size. On meeting with it in the field, noting its appearance when fresh, examining its genitalia and its puparia, and observing its habits, breeding and other—knowing *G. morsitans* thoroughly from all over the Territory and having had experience of that species in Portuguese East Africa—I was convinced at once that we were dealing with a new fly."

*Puparium* of *G. swynnertoni* (fig. 3, b).—The breeding-places of this species are dealt with elsewhere in this number by Mr. Swynnerton himself.*

Measurements of five perfect puparia examined in the position shown in fig. 3, *i.e.*, ventral side uppermost, with the tumid lips ("polypneustic lobes" of Newstead) directed away from the observer, are as follows :—length, 5·6 to 6·2 mm. ; greatest breadth (across region of sixth larval segment), 3·2 to 3·5 mm. A comparison with a series of *G. morsitans* puparia, examined in a corresponding position, shows that, although the actual dimensions of the puparium of the new species are but slightly greater, there are, as will be seen from the above figures, certain conspicuous differences. The most noteworthy of these are as follows :—

*Shape.*—Less regularly oval, the puparium of *G. swynnertoni* being widest across the region of the sixth larval segment.

*Tumid lips.*—Smaller than those of the puparium of *G. morsitans*, but separated by a wider notch.

*Notch between tumid lips.*—Closely resembling in shape that exhibited by the puparium of *G. pallidipes*, Austen.

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* See p. 333, and Plates xvi and xvii.

Fig. 1. Settled, close-grazed country near Magu Bay, Lake Victoria, showing in the foreground a village and its cultivated land fenced round with euphorbia.

Fig. 2. Open savannah-forest of "mhali" acacia with thickets near Nasa; puparia of *Glossina swynnertoni* were found under the log, which was exposed to continuous sunlight.

Fig. 1. The Mtukasa mbuga; cattle running safely in company with game in an open space surrounded with tsetse-infested wooding, which appears in the background.

Fig. 2. Thickets of *G. pallidipes* type, bordering a seasonally wet glade near Ngali; a severe attack by flies took place here, natives close to cattle being free, while those a few yards away were attacked.

Fig. 1. "Ilula" acacias and a *Combretum* (left centre) on the edge of a swamp south of Kahama in the *G. morsitans* belt; a heavy attack on motor cars took place here; *G. swynnertoni* found in similar places.

Fig. 2. On the lower Simiyu River; fringing savannah-forest formation of "mgu" acacia, unsuccessfully searched for tsetses.

Fig. 1. On the Simiyu River; fringing forest of *Ficus* and mgu in which, on the Rowana and Mbarangeti Rivers, much *G. brevipalpis* was found; *G. palpalis* absent; *G. swynnertoni* only at the fords.

Fig. 2. A small granite Kopje near Mtukuza, showing typical wooding; puparia of *G. swynnertoni* were found under the topmost rocks.

Fig. 1. Two leaning trunks of *Albizzia* in interior of thicket shown on Plate xiii, fig. 2; puparia of *G. swynnertoni* were taken under these and under the lianas.

Fig. 2. At Ngasamo; in each of the two small shelters formed by the rocks at the back of the two natives many hundreds of puparia of *G. swynnertoni* were found.

Fig. 1. A snake-like liana near Nasa; in the small space below the coils a number of puparia of *G. swynnertoni* were found.

Fig. 2. Near Nasa; numerous puparia of *G. swynnertoni* were taken in the position indicated by the net.

# THE ENTOMOLOGICAL ASPECTS OF AN OUTBREAK OF SLEEPING SICKNESS NEAR MWANZA, TANGANYIKA TERRITORY.*

By C. F. M. Swynnerton, F.L.S., F.E.S.

(Plates XII—XVII.)

Contents.



## I.—Introduction.

Information volunteered by Salim, the native headman of Basheshi, near Maswa, drew attention to the outbreak of sleeping sickness here described late in February 1922.

Dr. G. Maclean, the Medical Officer at Mwanza, at once carried out an energetic investigation. He found by blood examination that the disease (which had at first been regarded by the natives as "safula" or hookworm) was in fact trypanosomiasis. He ascertained roughly the extent of country that had been invaded by it already in the Simiyu–Duma area and, with the Senior Commissioner, at once took steps for the erection of hospitals in fly-free parts of the Sultanates most affected and for the segregation there of the sick.

It was obviously an exceptional opportunity to gain some idea at first hand of the combination of factors necessary to bring about an outbreak of human trypanosomiasis in epidemic form before these should have been masked by remedial measures —particularly so if it should be of Nyasaland type, and in the event, furthermore, of *T. rhodesiense* and *T. brucei* being finally shown to be conspecific.

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* This is a revision of a report sent to the Tanganyika Territory Government from Mombasa on 3rd July. The report (in order to be in time to assist decisions as to measures) was written in great haste, under difficulties and without much reference to my notes, while travelling to catch a steamer, and this paper should be regarded as replacing it.

I was especially anxious, with a view to future policy, to gain a first-hand knowledge of the probable relationship of the game to such an outbreak. Therefore, having consulted the Acting Principal Medical Officer, and having ascertained that from his point of view also, and Dr. Maclean's, my visit would be regarded as useful and welcome, I proceeded to Mwanza at the beginning of May, by car and on foot from Tabora to Smith's Sound, and thence by dhow. I found the Senior Commissioner, Mr. A. M. D. Turnbull, already considering the feasibility of wholesale evacuation and other important administrative measures which I shall describe. He accompanied me during the greater part of this investigation, and I was indebted to him everywhere for assistance that was invaluable.

We first sailed up the Speke Gulf with a view to examining the coast and the possibility of a connection, original or still existing, between *G. palpalis* and the outbreak. We then canoed up the lower reaches of the Simiyu River (Pl. xiv, fig. 2), again with the latter object, and, entering the fly-infested woodland two miles from Nyalikungu and (later) crossing the Simiyu, travelled between that river and the Duma to Zagayu. We crossed thence northwards to Luguru, the headquarters of Sultan Mwanilanga of Itilima, and returned to the lake coast through Maswa (the Ntusu capital), Ngasamo and Nasa. At Nasa we separated. This route had covered, very roughly, the piece of country in which cases were known to exist. Halts of from one to five days were made for the purposes of investigation.

Dr. Maclean and Mr. P. E. Tully, the Stock Inspector, joined us at Zagayu, from which centre Mr. Tully had been working a number of my bait-cattle and fly-boys pending our arrival. I am much indebted to him also for the supervision, later, of experimental clearing designed to ascertain the width necessary to render a road safe for traffic, for the marking of flies, and for other help, without which, in the short time at my disposal, I could not have attempted such work.

Finally, leaving Nasa on different dates, Dr. Maclean and I travelled separately to Ikisu—where we met and he took over from me my side of the investigation. Thence he went to Ikoma and the old *palpalis* area of the Mara, and I to Musoma, afterwards proceeding to Kisumu, Entebbe and Nairobi.

There was no lack of assistance. I have already mentioned Mr. Tully. Major L. G. Murray, M.C., commanding the 2nd Battalion, King's African Rifles, in Tabora, offered me the services of Lieut. Moore, V.C., a keen amateur entomologist who was anxious to help, and whose temporary seconding to tsetse work had previously been approved by H.E. the Acting Governor. The Medical Officer and I felt that he would be most usefully employed in combining entomological work with a search for sleeping sickness cases in the direction of the points—such as Seke and Uzinza—the infection of which would be most disastrous, but from which infection had not been reported. The Assistant Political Officers of Musoma and Mwanza (Mr. O. Guise-Williams and Capt. G. H. R. St. J. Owen, and Mr. G. F. Webster) were contributing on safari to the same useful search for cases and for the boundaries of the fly-areas, and were supplied with fly-boys to accompany them and collect. Mr. G. G. Griffiths, passing through the Chinyanga belt, most kindly collected and sent in flies and notes. Fourthly, at the request of the Senior Commissioner, I instructed one of my assistants, Mr. A. Loveridge, an entomologist and an expert and enthusiastic collector of small vertebrates, to proceed to the area at the end of August to undertake the watching of the grass-fires and the breaking up of the traffic in wildebeest tails that I shall describe as occurring about Ikoma and causing much dangerous movement of natives. He was also to assist Dr. Maclean with regard to the further entomological study of the fly, particularly as to its primary centres, and to collect on as large a scale as practicable the smaller vertebrates of the area in order to supply Drs. Duke and Maclean with abundant material for a study of the blood of the smaller potential food-animals of the incriminated tsetse. Dr. Maclean himself I found to be an enthusiastic yet cautious investigator anxious to work on every side of the problem.

All these opportunities for extended entomological investigation were particularly welcome at a time when this fly could still (for a few weeks) be studied in its normal relation to the infected population, and especially useful in the case of a tsetse, which I was convinced was undescribed and of the habits of which—so all-important in relation to control—nothing whatever was known. The assistance was well-timed also in relation to the need for an immediate knowledge of the distribution of the infection.

Native assistance was freely employed on this investigation, as it was felt that much might be at stake and that no time should be lost in ascertaining the distribution of the infection and the present limits of the tsetse. Expeditions composed of fly-boys with bait-cattle, to report eventually to Dr. Maclean and to continue to be employed by him for fly-work for as long as might seem necessary, were sent by me through the infested woodland to the Serengeti Plain, Lake Eyasi, the Tungu River, Ukerewe Island, and elsewhere. Only quite local expeditions had rejoined us before I left. I also, throughout the investigation, kept native shooters employed in obtaining material, particularly rock-rabbits (*Hyrax*) for blood examination by Dr. Maclean and to keep me well in touch with the presence or absence of game.

I am indebted for information bearing on this investigation and other direct assistance to the persons already mentioned, to Capt. B. D. Armstrong and Capt. R. G. H. Wilson, D.S.O., M.C., of the 2nd King's African Rifles; to the Senior Commissioner, Tabora (Mr. H. C. Stiebel); to the Assistant Political Officer, Chinyanga (Mr. G. F. Bell); to the Rev. A. X. Davis; to the Senior Commissioner, Medical Officer and Sanitation Officer, Kisumu (Mr. H. R. Tate and Drs. G. R. H. Chell and F. J. C. Johnstone); and to the Principal Medical Officer, Principal Sanitation Officer and Government Entomologist, Nairobi (Drs. J. L. Gilks and A. R. Paterson and Mr. T. J. Anderson).

It will be seen that the outbreak offers several points of exceptional interest. The fly responsible for it—"sali" of the local natives—is of the *morsitans* group, yet the disease is in epidemic form and six and a half degrees farther north than the most northerly recorded case of *Trypanosoma rhodesiense*.

Whether the parasite actually is *T. rhodesiense* or whether (as a little of the evidence suggested) it might be *T. gambiense*, was being studied by Dr. Maclean and has, since I left, become the subject of a special investigation by Dr. H. L. Duke, who was lent by the Uganda Government for this purpose. It is to be hoped that definite evidence as to the relations of the trypanosomes and as to the actual importance of each of the two modes of transmission may emerge from his results, which must in any event be of the very highest interest.

Further outstanding points were the dense stand of very young woody growth that is threatening to convert the greater part of the belt of wooding into thicket; the effect of population in completely clearing great areas; the evidence therefrom of the number of settlers required to keep down tsetse automatically, and the possibility that local surpluses of men and cattle might by organisation and inducement be diverted to the suppression of tsetse belts; some evidence for the probable effectiveness of merely partial clearing; the peculiarly anthropophagous habits of the fly; the free "following" of female flies across open barriers; the evidence that the fly ranges out to conspicuous trees, etc., in the open; the fact that it differs from *G. morsitans*, its nearest described ally, in certain important details; the position, in the bush villages, as regards the possibility of much direct transmission of the trypanosome; the apparent man-to-man nature of the infection, travelling chiefly, it appeared, outwards from a centre; and, most important of all, the light which the history of the outbreak appears to throw on what would be the effect (1) on the tsetse, (2) on the trypanosomiasis of man, of a destruction of the game. I believe that the much-needed experiment in game-destruction has here, for practical purposes, been carried out, and that we know the result.

The information I have included in the map on the distribution of fly and sleeping sickness in South Kavirondo is taken from maps which were kindly placed at my disposal in Kisumu and Nairobi. The map, and this paper generally, should be regarded as preliminary and provisional only, a basis for correction and addition by the medical, political, and other officers who are continuing to work on the problem.

The specific names of certain of the plants referred to in the paper are provisional also. They will be revised and added to when my plant collection has been worked out. I am much indebted to Dr. A. B. Rendle, F.R.S., Dr. H. Harms, Dr. M. Burret, Mr. E. G. Baker, and particularly Mr. C. Norman, for their kind assistance in connection with the naming.

## II.—The Country generally.

As regards vegetation, the country is divisible primarily into (1) perfectly, or nearly perfectly, open country, free from tsetse (Pl. xii, fig. 1) ; (2) acacia wooding, infested nearly throughout by a new tsetse of the *morsitans* group (Pl. xii, fig. 2) ; and (3) *Brachystegia* savannah forest, also fly-infested.

The bulk of the open country itself may be described as " suppressed " acacia wooding. The suppressive factors at work are merely temporary, and their removal or weakening even for four or five years would, and does, allow this wooding to grow up. This results in continual modification in the distribution of the two contrasting types. Each of them, however, covers a great area of country, and their present distribution is shown approximately in the accompanying rough map.

No primary forest was seen. Though it occurs, it is said, on Kome Island (where is a forest reserve) and, in its mountain form, on Oldeani and in some places in the volcanic area north of the Kenya border, both general indications and native information as to past alternations of acacia savannah and settlement suggest that it is long since it was exterminated in the bulk of the country I have shown on the map. But an enormous area of " miombo " or *Brachystegia* savannah forest, already described and figured by me under its Shangan name " itondo " (Bull. Ent. Res., xi, p. 320, Pl. xvi) fills the west of Tanganyika Territory and borders the special area I am here dealing with on its west and south. It is infested throughout by *G. morsitans*, and its possible infection constitutes the greatest danger of the present outbreak.

The general geological formation is granite. Granite boulders, and kopjes and hills composed of them and reminiscent of Mashonaland (Pl. xv, fig. 2), are scattered thinly or in groups over both the wooded and the open areas and everywhere crown rising ground. Hilly plateaux, a small one at Kilalo, a greater one in Ushashi and the country to its north, occur in the granite.

Schistose, diorite and diabase hills of more rounded outline occur at Zagayu (Mount Sansui) and at Ngasamo, and (as a view from the last-named hill showed) become very general in the direction of Ikoma. They are associated with a red soil that contrasts with the grey and sandier soil of the granite.

North of Ikoma both the above-mentioned formations are said to give place to ancient shales and quartzites that fail to reach the coast but extend far into Kenya Colony. These are associated on the whole, it would appear, with lighter types of bush. Doubtless not everywhere, for where the Mara crosses the border there is, at the foot of the Isuria Escarpment, an area inhabited by *G. pallidipes*.

On the coast just north of the Kenya border the intervening granite gives place to the volcanic rocks of the Tertiaries and generally loftier country. The change in the form of the hills is very noticeable from the Lake. A similar geological, not physical, change takes place also on the eastern border of the three great bush-covered Sultanates of Ututwa, Kanadi, and Meatu, on reaching the Serengeti Plain. The change in each case appears to coincide with a change in the general vegetation.

The elevation of the country varies from 3,726 feet at the lake level to 4,500 feet and more on some of the more prominent hills and plateaux, and as much as 6,600 feet at points north-west of the Isuria Escarpment.

German charts show the main area with which we are here concerned as possessing a break in the rains, a very strongly-marked dry season and a rainfall of 20–30 inches. Passing south-west and south the dry season remains marked, the break in the rains gets weak and disappears, and the rainfall rises to 30–40 inches; this area appears to coincide approximately with that which is covered with *Brachystegia* wooding. West of the Lake, in the Bukoba area, the dry season is shown as shortened, the break as weakened, and the rainfall at a figure of 60–80 inches.

Ukerewe, the town and Sultanate of Mwanza and the northern portion of Uzinza are shown in a category intermediate between the last two and with a rainfall of 40–60 inches. That is, the dry season is more marked in the main (Usukuma) fly-area investigated than at Mwanza, and the rainfall just half, though the same fly occurs on the Ukerewe mainland, where the rainfall is apparently the same as at Mwanza. The point is of importance in relation to the possibility of effective grass-burning.

The dry season was commencing when I arrived early in May, and the climatic conditions contrasted strongly with those of the same months at Entebbe. This difference is perhaps reflected in the persistence, in spite of probable vicissitudes, of some of the splendid primary forest of the latter region, in the always green grass of Entebbe and the northern islands, and in the contrast of both with the low, dry, savannah woodland and xerophilous shrub formations of Usukuma (Pl. xii, fig. 2).

## III.—The Open Country.

This includes (1) rolling, grassy, undulating country, close-grazed by numerous small herds of cattle and dotted over with millet fields and village-enclosing rings of black-green *Euphorbia*—great areas that are one cleared field and owe their nearly complete freedom from bush to the presence of a long-concentrated human population and the browsing of stock (Pl. xii, fig. 1); the granite kopjes of this open country in a few places carry bush or scrub, but, even then, owing to their isolation, harbour no fly; and (2) great mbugas (Pl. xiii, fig. 1), kept open and, in parts, fly-free by excessive seasonal moisture or by the browsing of game. The outstanding examples are (*a*) the extensive mbugas of the Rowana and Mbarangeti, that form a broad, relatively clean and useful break across the north of the infected thorn area from the Lake in the direction of Ikoma, and (*b*) the Serengeti Plain, which bounds this area on the east.

Small vleis or mbugas (seasonally swampy glades) are scattered very freely through the woodland area generally. The nearest short English rendering for a "vlei" (South Africa and Southern Rhodesia), "dambo" (Nyasaland), or "mbuga" (East Africa) would be "seasonal swamp." On the other hand, "mbuga" includes naturally open land that is not swampy, and all three words, I believe, may include open land that is permanently swampy.

## IV.—The Acacia Thorn Area.

The general acacia area includes—and encloses—a number of woodland formations:—

(1) *Acacia Savannah Forest.*—There are several actual acacia-dominated formations. Each is dominated by a different species of the genus and is confined to particular conditions, especially as regards drainage. These formations between them cover the uncleared country with savannah wooding and tree savannah and the cleared country with their live roots. The five most important formations are:—

(*a*) That of the fine tall "mgongwa" acacia on the best-drained deeper soils.

(*b*) That of the dainty yellow-flowered "sesa" acacia (*A. stenocarpa*, Hochst.).

This dominates on the higher hills, as on Ngasamo and on the Ushashi plateau, and is far more freely intermixed with broad-leaved trees than any of the others. On the Ushashi plateau the broad-leaved trees predominate and, with a *Combretum* (near *tetraphyllum*, Diels) as their commonest element, they include also such trees and shrubs as *Erythrina tomentosa*, R. Br., *Kigelia, Anona, Cussonia, Grewia, Rhus glaucescens*, Rich., *Rhoicissus, Parinarium*, and two species of *Vitex*. This bush is in places sufficiently close to make one marvel (in spite of the relatively high elevation) at the absence of fly and the presence in it of numerous cattle. It is very distinct from anything else seen on this safari. The granite heads that here and there project are densely thicketed, but old euphorbia hedges indicate that the country was once more densely settled than now.

(*c*) The formation of the most xerophilous of the acacias—the grey-leaved "mhali" (*Acacia spirocarpa*, Hochst.), often with rock below and therefore somewhat liable to water-logging in the rains and an extreme of dryness in the dry season. This type clothes the ground round and between the granite kopjes and (interspersed somewhat with mgongwa) forms (i) extensive fly-infested forest on poor, sandy, badly-grassed granite soil in Nasa and Msanza Mdogo (Pl. xii, fig. 2), and (ii) similar forest, but without fly, in granite country at the back of Musoma.

(*d*) The swamp-fringing acacia, the "ilula" (*Acacia drepanolobium*, Harms, and an allied species), a small, straight, often unbranching tree, its twigs studded with large round galls that house ants of the genus *Cremastogaster*, grows somewhat densely, yet without giving much shade, on the margins of the seasonally-wet mbugas. It is sometimes associated with a *Combretum* of the *tetraphyllum* type (as in Pl. xiv, fig. 1) and ventures, in clumps, into parts of the mbuga itself.

(*e*) The larger, shadier, blacker-foliaged "tulangoi" (*Acacia hebeoladoides usambarensis*, Harms). This may be associated with the ilula, or with the margins of ill-drained spots on the borders of mgu country, or it may itself, more rarely, locally dominate. In the latter event it tends, I think, to be rather specially associated with tsetse.

The acacias (regarded alone—for I have yet to touch on thickets) form open to fairly open wooding, and are high where there has been no recent cultivation, low and scrubby (but growing up) on the sites of abandoned fields. Their most widely distributed associate, rather linking the mhali and the ilula in its tastes but occurring also with the mgongwa, is another of the Mimoseae—the "mpogoro" (*Albizzia hypoleuca*, Oliver); while a small stubby tree, the "tinji" (*Odina* sp. ?), an early leaf-shedder, was abundant on many vlei edges, being more daring in the matter of badly drained moisture than the mpogoro or mhali, yet less so than the ilula. It is always gregarious, but it may be found in association with any of these species or bordering a swamp itself. The fly had already left it in June.

(2) *Fringing Forest.*—To be distinguished from the foregoing tolerators of relatively ill-drained ground are the true (albeit secondary) fringing formations of the lake and the rivers, and in particular the rather fine fringing savannah forest that is dominated by the tall and handsome "mgu" (*Acacia campylocantha*, Hochst.) (Pl. xiv, fig. 2). This grows on deeply cracking cotton soil that is liable to be extensively flooded in the heaviest rains, and that even in June, though dry, stood out as a bright green ribbon of tall, coarse grasses; it thus contrasted sharply in the distance with the dry reddish grass of the adjacent mhali formation, and along the lower reaches of the Duma in particular was two miles or more in breadth.

The other fringing formations are (*a*) the mixture of ambatch, *Grewia, Hibiscus*, reeds and papyrus that covers the broad Simiyu delta in Magu Bay and (papyrus chiefly) partly blocks the mouths of the other large rivers; (*b*) the close fringe or hedge of bushy Vernonias(?) that, below the upper bank, lines the rivers along sandy reaches, and appears in Plate xv, fig. 1, in its usual position in relation to the heavier wooding; and (*c*) the combination of fine mgu acacias, large, shady *Ficus* and dense under-shrubs (same Plate and figure) that tends to reproduce the shelter-conditions of primary forest and should, and on some rivers does, harbour *G. brevipalpis*.

(3) "*Enclosed*" *Formations*.—These are (*a*) the broad-leaved, very distinct formation of trees and shrubs (*Grewia*, *Sterculia*, and many others) that closely fills the interstices between the great boulders of the kopjes and (on the island at Musoma and the coast opposite, as well as at points on the Mwanza Gulf and elsewhere where kopjes are half submerged) comes down to the lake and harbours *G. palpalis*. This formation (Pl. xv, fig. 2) takes the guise of little rocky islands and archipelagos, not thorny and devoid of acacia, dotted through the acacia thorn woodland; (*b*) the thickets, which are, in part, composed of the densely growing seedlings of the savannah trees, and partly, more or less low, dense shrub-thickets (Pl. xiii, fig. 2), in places scattered, in others more massed. Such thickets occur throughout the woodland, and with the aid of the sapling thickets (which they invade) are tending to cover the entire area with the quite intractable type of tsetse-infested bush that occurs, for instance, over great stretches of country between Dar-es-Salaam and Morogoro. They often enclose and are overshaded by from one to many large or small acacias (as in Pl. xii, fig. 2), doubtless owing to the fact that the grass in the shade of a tree dries later than the grass outside, escapes the weak fires of the early months, and allows shrubs and saplings to obtain a start. They comprise, especially, species of *Grewia* and *Commiphora*, *Acacia verek*, Guill. & Perr., and in places *Markhamia lanata*, the small-leaved, thorny trailer (*Harrisonia abyssinica*, Oliv.), and (especially in the drier situations and in association with *A. spirocarpa*) *Kalanchoë*, *Aloë*, *Sanseviera*, and much of the fleshy-looking liana (*Strophanthus* sp.) that is shown in Plate xvii, fig. 1, and that sometimes coils all over the thicket floor and shelters both tsetse and their puparia; (*c*) a kind of thicket that I found containing flies in small numbers near Zagayu and north of Kahama and that occurs here and there throughout the area, and particularly on the margins of certain seasonally damp spots, is composed of large, round brakes of a trailing *Combretum* that gives a little the effect of a much-enlarged blackberry bush, and may or may not occur in connection with the types of thicket I have referred to already.

Reproduction is only too good. An enormous amount of young growth (*Acacia* and *Albizzia* especially) is everywhere springing up more or less densely, and unless this can be kept down by systematic burning, the whole area will become as thicketed and as heavily fly-infested as patches of it now are. I cleared of grass two squares, each of nine square yards. In one I counted 95 young trees, and in the other 77. These squares were not exceptional, but represented the present position over broad patches of country. Some early grass-fires had already taken place at the time of our visit and had killed not a twig of these little trees that an October fire would have burned to the ground. The results of past ineffective fires were seen in places where masses of these small trees were already growing up and forming thickets.

## V. The People.

The people generally, for our present purpose, are to be distinguished into (*a*) cattle-keeping cultivators, who live relatively thickly in the cleared areas, and who, where near enough, visit the woods for wood, bark rope, water, hunting, fishing, young birds and honey, medicines, ancestor worship, and material for the Ifubo or silver-leaf dance; and (*b*) hunting and fishing cultivators, who, owing to nagana, can keep no cattle, and who live in a more scattered fashion in the woodland area itself. It is a most interesting point that they have been enabled to do this, as they themselves state, by the freedom they have now obtained from the old tribal raids and clan warfare that forced on them the concentration that has usefully cleared so much country; and they have been induced to do so by the loss of their cattle in the epidemics that have accompanied the European régime during the past thirty years. Game skins and fish nets may be found in most huts of this section. The fruits of *Strophanthus eminii*, Asch. & Pax., are used for the manufacture of arrow poison by every native in these parts and are found lying in the villages. Pits, game nets, and heavy rope snares are also employed. Along the whole lower course of the Simiyu

and at the points at which we saw the Simiyu and Duma higher in their courses large stationary fish traps, often in the form of a ditch and protected against crocodiles by palisades, were abundant ; fish baskets are in places supported against the current and floods by stone dams across the river ; and during our canoe voyage we came on anglers with rods, one at least of whom had been extraordinarily successful. The Wantusu, in particular, whether in the clean areas or in the woodland, are clothed almost entirely in well-brayed skins of game ; these also cover their beds. Long necklaces made from discs cut neatly from the shells of ostrich eggs are worn by everyone, and whole ostrich eggs are mounted as charms on the summits of the huts.

It follows from all this that those people who live in the woodland, and those who live near it and enter it for the same purposes, are nearly as available to the tsetse as food-animals as the game itself ; they are also far more available than the game when it is scarce, and must then carry great numbers of tsetses to their villages.

A further division of the people that may be of great importance in relation to the spread of sleeping sickness is tribal. They may be divided into (*a*) the Bagwe or (Kiswahili) Wasukuma, the real occupiers of the sleeping sickness area ; and (*b*) members or sections of other tribes permanently settled amongst them. More will be said on this point in Section XX.

## VI.—The Other Hosts of the Fly.

As regards game animals, the area is divisible into three parts. The first line of demarcation passes a little north of the Duma, through Ngasamo and Nasa, and swings southwards round the cleared area in which are Maswa and Luguru, though giving it a fairly wide berth. North and east of this line game of most kinds, excluding elephant and situtunga, begins to become abundant until, in the Ikoma and Serengeti areas, it is very abundant indeed, particularly wildebeest, zebra, Thomson's and Grant's gazelles and topi, and carnivora are proportionately abundant.

South and west of the line I have described, that is in the woodland areas most closely associated with the outbreak, game animals were exceedingly scarce. They consisted, in order of apparent scarcity during our visit (I prefer to put it in this way, as there was no trace of " abundance "), of situtunga (alleged to be very rare, at spots with papyrus), bushbuck, giraffe, reedbuck, waterbuck, duiker, impala, ostrich (localised), roan antelope and eland (not many of either), topi, hartebeest and zebra. Even in this impression is included to some extent the game that occurs on the border line of abundance, as the ostrich and zebra near Kilalo. The Duma—or rather north of it—is the present southern boundary of the rhinoceros, though a single individual is said to haunt Ndagalo and Igombe. Buffalo were so plentiful here formerly that one person (so an old man told me) killed thirty at one place, but they have never been allowed to recover from the original rinderpest. They are absent from the Simiyu side of the area, and are in numbers " only beyond Kanadi." A few small parties, alleged migrants from the Mbarangeti, occur sometimes on the Duma on the borders of Nasa and Ntusu, or appear for a time near Ngasamo ; and wildebeest, formerly abundant right down to the Simiyu, are now scarce, but still arrive in the late dry season in Nasa and Ngasamo. Impala are plentiful at Nasa. Warthogs were present at various points, though nowhere in any numbers ; bush-pigs (and this was remarkable) were extremely scarce, except (it was said) in the very limited area of the Nasa hills.

Game was particularly scarce on the Simiyu side of this area, as was indicated by personal observation, by the failure of our shooters, by native statement, and by the very high percentage of female tsetses taken daily and the special avidity of the flies. Practically all game animals shot in this section were obtained in the Mtukuza mbuga, in which such game as was in the surrounding bush areas congregated, and the only giraffe seen by any of us and the only appreciable traces of eland or roan antelope (outside of the mbuga) were in an uninhabited piece of country towards the centre of the area. While this Simiyu game would appear sometimes, perhaps

annually, to be reinforced (and game, though scarce, is probably less scarce than it was at the time when the sleeping sickness began), native statements show that the foregoing is nowadays the normal relative position. The natives admit that they had much reduced the game within this ring of population even before the war; statements show further that, here as everywhere, the relaxation in the enforcement of the game laws that accompanied the war resulted in more intensive hunting, and that this became yet more intensive, especially in the neighbourhood of the greatest population, during a famine that took place in 1917–18. The passage of troops through this very area just before the famine will probably also not have been without some effect. Such further explanation as is needed of the special scarcity of game in this area is supplied by the fact that the great annual game movements in search of water are from the north and east. That from the east is intercepted by the heavily settled strip of Maswa and Luguru, and that from the north is checked by the villages north of the Duma, the area of dense settlement that has grown up about Kilalo in the last twelve or fifteen years, and, until 1917, the mine at Ngasamo. This employed some hundreds of labourers and the shooting carried on there for meat must have constituted it a strong link in the barrier. Even its shutting down, backed as it was by a certain number of villages that remained, does not seem to have led, up to the present, to any great irruption of the game.

It will readily be seen that we have here the position that a great piece of tsetse-infested woodland was surrounded with a barrier and the game within it enormously reduced. Neither the barrier nor the game destruction were by any means absolute, but the contiguous native population of keen hunting tribes was very great, and guns were present in addition to highly effective native weapons and methods. The resources of destruction that were turned on to the game of this hemmed-in area were at least as great as could have been marshalled for any experimental destruction, and the killing was very persistent, so that it is probable that, by the end of the famine, the game had been brought down to the minimum below which, in savannah forest country, it is not humanly possible to bring it, excepting by means of fairly heavy settlement.

It may here be noted that the clear area of Kilalo as shown in the map includes some half-cleared country on its east and a natural mbuga on its west. Such clear ground as there is immediately round the Ngasamo Gold Mine is due partly to clearing for mining purposes, partly to natural mbuga.

The third division of the Usukuma-Musoma area as regards game is that comprised within the closely settled country. This is nearly destitute of game and is avoided by it, though zebra and ostrich come out in places from the bush to the nearest crops, and the narrow cleared littoral of Nasa is traversed by game seeking water on the Lake when other sources fail.

The granite kopjes have a fauna of their own. They are probably unattractive to ordinary game, being for the most part (Pl. xv, fig. 2) densely clothed with rocks and trees, but rock-rabbits (*Hyrax*) of two species are common, and so in places are baboons. The latter appeared to be the only animals that visited some kopjes beside Ngasamo in which my natives found tsetse puparia (mostly empty) under every suitable rock to the number of over 2,300 in a couple of hours, and round the bases of which baboon tracks were everywhere conspicuous—as indeed they were in the bush near Nasa, in the lower rocks of Mount Baridi, and in some other places in which the puparia abounded. Occasional klipspringers, leopards, porcupines and hyaenas frequent the kopjes; two species of lemur were found; and bats were in places hanging in some numbers in rock-clefts that, to judge from finds of puparia, were sometimes utilised also by the tsetses.

Crocodiles are abundant in the rivers and hippopotamuses are present in places, but neither animal appeared to be in appreciable contact with the fly that was associated with the outbreak.

One final point may be referred to. In Musoma (as Capt. Owen informed me), except in one area, game is abundant where tsetse is absent and tsetse abundant where game is scarce. This may represent a temporary phenomenon, as Dr. Duke, who took part in the operations here against Neumann in 1917, speaks (Bull. Ent. Res. x, p. 11) of an abundance of game between Ikoma and the Mara, and Ikoma and Olgoss, both fly areas. However, the influence of game, when really abundant, in keeping down bush that might otherwise harbour tsetse has been referred to and cannot be doubted, while apparent evidence of its avoidance of established tsetse-harbouring bush where an alternative exists close by was seen by ourselves, and either factor might contribute to the phenomenon referred to by Owen.

## VII.—The species of *Glossina* present.

**1. Glossina palpalis,** R.-D.

In the Mwanza Gulf there are stretches of granite-kopje wooding that come to the shore both on the mainland and some islands, and Fiske and Marshall took *G. palpalis* in the latter. From Mwanza to beyond the Rowana River, the Lake and river front that covers the sleeping sickness area, no sign or news of this fly could anywhere be found by us. With the exception of a few very small points, some of which were carefully searched, the coast from Mwanza to Nasa has been completely cleared of woody vegetation by native settlement. The islands generally of the Speke Gulf and the margins of the mainland on its north, as seen from the dhow, also appeared to be clear on the whole, but in Nasa the mhali acacia wooding (Pl. xii, fig. 2) comes to the shore and, as a broken marginal to submarginal strip, stretches to the Rowana and beyond. Here again, as in Magu Bay, I searched carefully by canoe, coasting close and sometimes landing and searching for the fly and its puparia, but without success as regards *G. palpalis*.

The vegetation at Kianzi point and the little Yamagata Islands in Magu Bay closely resembled vegetation in which I had taken *palpalis* elsewhere, but these widely isolated little points of wooding on a clear coast are obviously as insufficient for the requirements of the fly as are the isolated wooded granite kopjes and small *Acacia* woods of Sultan Tshasama's settled country for those of *morsitans*, nor were there, even in the mhali north of Nasa, any patches of "massive" wooding to serve as centres of distribution. Fiske has mentioned this also in a report, I believe unpublished, on the Cruise of S.S. Sir William Mackinnon into Tanganyika Territory in 1920.

Neither, however, could *palpalis* be found in the mgu wooding (Pl. xiv, fig. 2) that borders the lower Simiyu, nor in the far more likely fringing forest of shady *Ficus*, some mgu and thickets of dense green *Grewia fallax*, a *Gardenia* of the *thunbergia* group and the thorny shrub (*Harrisonia abyssinica*) that borders the Mbarangeti and Rowana (*cf.* Pl. xv, fig. 1), though these rivers are full of hippopotamus and crocodiles and infested by baboons.

On the other hand my natives took *palpalis* and its puparia in numbers on the small Mgasiro Island in Mara Bay near Musoma (where it was known to exist), and Dr. Davey had already found it at Musoma point. More wooding of a more or less dense nature comes to the shore in Mara Bay than in the Speke Gulf, and (as could be seen from the steamer) this condition tends to recur here and there till one turns into the Kavirondo Gulf.

Fiske and Marshall also, in 1920, failed to find *palpalis* in the Speke Gulf from Mwanza right round to Nafuba Island off the Ukerewe mainland. Here it was found both on the island (densely) and the mainland near, the conditions (shelter and lack of cultivation) having become favourable. Extensive uncultivated beaches of the Ukerewe Island shore eastward of Wiru Island were found very densely infested, as were parts of Kome and the islands to its west.

So far as the fly on the rivers is concerned, I am not clear as to the position on the Mara River, which Dr. Maclean was about to revisit, but Dr. Davey had failed to find *palpalis* on the Mori River, where the very extensive clearing carried out by the Germans was still effective ; but I was informed in Kenya that on the Gori and Kuja Rivers just north of the Tanganyika Territory border the position as regards infestation remains much as it has always been and as it is shown on the map. The Kuja flows through heavy bush and forest and has been reported by Dr. J. O. Beven to be infested in its whole extent to Ramba, where are grassy uplands. The Gori (Magori) had forested banks as far as he followed it.

2. **Glossina brevipalpis,** Newst.

This fly and its puparia, many of the latter living, were found in numbers in the denser thickets fringing the Rowana (*cf.* Pl. xv, fig. 1), and especially in the deep narrow cuttings made by hippopotamuses through the steep bank. Crocodiles were numerous also. *G. brevipalpis* also occurred on the Mbarangeti and (in smaller numbers) on the small Nyakurunduma stream an hour north of Tshamagasa, and in the mhali acacia wooding with much dense thicket that occurs from Tshamagasa northwards as the marginal to submarginal fringe to the Lake that I have referred to. Between this fringe and the Lake (north of the Mbarangeti) is a very narrow cleared strip in which cattle are kept, it is said safely. Contrast with this a position near Nasa where, with a more adventurous fly (*G. swynnertoni*) at the back of a narrow cleared fringe, cattle cannot be kept.

During the working of the Simiyu area a solitary *G. brevipalpis* was found at the bottom of a cyanide bottle, but no fly-boy claimed it, and it was unsafe to assign to it either date or place. I was surprised at our failure, despite careful search, to find either *brevipalpis* or its puparia in the rather heavy fringing forest on the Simiyu that is shown in fig. 1 of Pl. xv.

On Mgasiro Island, in Mara Bay, we took a considerable number of *brevipalpis* puparia, though we failed to find either the fly or its puparia in the very extensive acacia woodland and granite kopjes, in which cattle run, behind Musoma itself. The search was perhaps insufficiently prolonged to be conclusive. It would be interesting to know whether on Mgasiro this fly fed on crocodiles.

3. **Glossina fusca,** Walk.

As Mr. T. J. Anderson informs me that there is no doubt as to the fact that the large tsetse found hitherto north of the Kenya border is *G. fusca* only, and as there is equally no doubt that the specimens taken by myself and my native collectors as far north as Mara Bay are *brevipalpis*, it would seem that the Kenya-Tanganyika border may at this point constitute approximately the dividing line between these two flies. It may be a matter of the bush conditions associated with the volcanic and the granite formations respectively.

4. **Glossina pallidipes,** Austen.

We took a solitary male *pallidipes* on my bait-cattle beside a small glen lined with a narrow strip of bush with woody, sclerophyllous, ravine-type undergrowth (*cf.* Bull. Ent. Res., xi, p. 319) at 8 a.m. on 16th June. It was taken just after and just above the last two flies of the *G. swynnertoni* belt at the bottom of the hill—the south side of the Mount Baridi (Ushashi) escarpment. Another, showing close approach in its genitalia to *G. longipalpis*, was taken on the 18th by Dr. Maclean at Uhemba village (not Uhemba district) east of Ikisu on the same plateau. It is shown much too far east in the map. Further north, on the Kenya side of the border and also on ours, definite *pallidipes* areas exist, and this is the only fly of the *morsitans* group that is known to occur anywhere in Kenya.

The fly area shown in the map south-east of Shirati is one of *pallidipes*, Dr. J. B. Davey having taken this fly in small numbers in country that was on the whole open and in which numerous cattle were present from Bukina (two hours from Shirati) to Kinesi. Dr. Beven (unpublished report) found it in dry thorn bush (1) with *G. fusca*, along the south bank of the Kuja River, some distance from the water, from near Welbondo to a short way beyond the Gori; (2) in Kasiganga, between Nyangoma and Moita, in numbers that precluded the keeping of cattle; (3) heard of only, probably this species, in the Lambwa valley. I have already referred to the Isuria-Mara belt.

It will be noted that we first met *G. pallidipes* on reaching the border line (*a*) of a better rainfall area; (*b*) of a less xerophytic vegetation; and (*c*), perhaps only indirectly important, of a more mountainous area.

5. **Glossina swynnertoni,** Austen.

The only tsetse that could anywhere be found in the known infected area by a most thorough search, stimulated by means of rewards and carried out by a large number of natives and, in all, 30 bait-cattle, and the only fly that had been taken therein previously to my arrival, was a species of the *morsitans* group.

This tsetse, referred to hereinafter as "the fly," has been named by Mr. Austen after myself as this paper goes to press. I greatly appreciate the linking of my name with a subject in which I am so keenly interested, but I can lay no claim to having first taken the fly. The Germans took it for *G. morsitans*; Mr. Fiske told me that he took numbers, presumably of this fly, at Nasa over two years ago; and the earliest flies now in my possession were captured by Mr. G. G. Griffiths in the Seke-Chinyanga belt early in March of this year. Dr. Maclean, the discoverer of the outbreak, and, helping him, Mr. Tully and (I believe) the Administrative Officers, also took many in that and the following month.

It is nearest to *G. morsitans*, though in certain characters, both in the adult fly and the pupa, it resembles the flies of the *pallidipes* sub-group. It does so also in its preference for breeding in thickets of the type frequented by *pallidipes* (*v.* p. 333). It resembles *G. morsitans* in its savage attachment to man, in the relative absence of game. I have seen no tsetse that so readily attacks man with cattle present, and no fly the females of which travel so freely and far on man. Both traits were undoubtedly due largely to the fact that in the places in which they were specially prominent man had successfully replaced the game as the fly's chief food-animal. In the order of readiness to attack man the tsetse on which I have done most work may be ranged thus: (1) *G. swynnertoni*; (2) *G. morsitans*; (3) *G. pallidipes*; (4) *G. brevipalpis*; (5) *G. austeni*.

From what I have read of *G. palpalis* rather than from my very few days' work on it (on Lake Tanganyika, in particular), I would bracket it with the first two of these species.

*G. swynnertoni* inhabits, to the exclusion of *G. morsitans*, a solid tract of country that is cut off from a partly surrounding arc of pure *G. morsitans* by a strip of native cultivation, and it may prove to come into contact with the latter fly east of Chinyanga or on the Nanga. It is remarkably unvarying in appearance and in its genitalia, and *G. morsitans* (as my material shows) varies much even in single localities, an extreme form showing an approach to this fly in colour-pattern, though not in colour. It looks like a case in which a variety has become fixed as a species through long isolation. On the other hand, the occurrence of an unvarying fly possessing characters in common with *pallidipes* on the border that finally, on the north-east, separates the distribution of much-varying *G. morsitans* from the unmixed distribution of relatively unvarying *G. pallidipes*, suggests a greater age for it, and this view is supported further by the consideration that the barrier of native settlement that in one part only slightly, and perhaps not entirely, separates the two flies can hardly be of such age as to have brought about the fixing of a species.

The main area occupied by this fly in East Mwanza would appear to coincide with that of the main acacia woodland area shown in the attached rough map. In the north it occurred in the strips of mhali-*Combretum-Grewia* wooding at the immediate foot of Mount Baridi (Ushashi escarpment) and its pupae under the lower boulders of the mosaic that covers this hillside; and the same fly, taken again in numbers by two of my natives, has been sent to me by Mr. Turnbull from the mainland of Ukerewe since I came to England. Dr. Maclean took it an hour east of Chamliho.

In these circumstances it would seem likely that it is the chief fly that occurs about Ikoma and northwards as far as Bwasi—also that it is the fly that is said to infest the bush in the centre of Ukerewe, though my native collectors failed to find fly there. With reference to the area about Lake Eyasi that is shown green in the map, Mr. E. D. Browne, the Senior Commissioner of the Arusha District, wrote to me in a letter, dated 10th September 1921, "I am well acquainted with the area in different seasons. I believe that only *Glossina morsitans* infests the Yaida Valley and is of course rampant to Eyasi and probably all round this lake, except possibly at the extreme north-east corner, and even there I am doubtful of its absence at all seasons." It becomes doubtful now if the fly referred to and that on the Manyonga River (where "and," in the map, should read "area") is actually *G. morsitans* or if it is *G. swynnertoni*. The latter species, as I have said, is present in the Chinyanga-Seke belt, which is separated from the area known to be infected only by the comparatively narrow populated strip of Nung-hu and by a strip of thin thornland, as to the infestation of which I have at present no information (*v.* map).

Its belts, then, would appear as at least two compact areas of *Acacia*, one large, one small, which have been split off by mbugas and population from the great western fly-belt of *Brachystegia* inhabited by *morsitans*. From the Mbarangeti and Ikoma northwards the larger is broken into blocks by open mbugas, cleared areas of heavy population, and such uninfested wooding as that behind Musoma, the latter being free perhaps through having been surrounded since it was last a cleared area by fly-proof barriers. The smaller belt, at Chinyanga, consists of at least one considerable "island" in the inhabited country between the main belt and the *morsitans* belt.

The fly is completely absent from the continuously cleared areas, though individuals are carried in for some distance, and the villages within half a mile or a mile of the bush would occasionally receive invasions of half a dozen or a dozen at a time travelling on people who have been hunting, fishing or wood-cutting. Cases of nagana occur in herds living beside the bush or habitually driven through a piece of it to water.

### 6. **Glossina morsitans,** Westw.

No other tsetse than *G. morsitans* has to my knowledge been taken in the strongly infested *Brachystegia* area, the margin of which, very roughly indicated, is shown brown in the map. The genitalia of the flies there taken show sometimes the *morsitans*, sometimes the *submorsitans* characters. The margins and outlying patches of the area do not always contain *Brachystegia*, and nearer Lake Tanganyika this great *Brachystegia* area is divided by the acacia-dominated formation of the northern part of the Rukwa depression. Yet in this also I took nothing (in December 1921) but *G. morsitans*, and this fly inhabits extensive acacia-formations elsewhere in the Territory also, as in the Morogoro District. So that while *morsitans* is, I think, probably *par excellence* on this side of Africa a *Brachystegia* fly, it cannot be merely the domination of *Acacia* which excludes it from the Chinyanga-Usukuma fly-belt. Similar considerations apply to *G. pallidipes*, which in some belts occurs with *G. morsitans* and in some separately, and it would appear to require merely a little intensive oecological work of a comparative nature to show us the essential requirement of each of the three species.

## VIII.—The Seasonal Distribution and Preferences in Vegetation of the Fly.

When I left the belt in mid-June, the fly was still dispersed through the bush. "Tinji" (*Odina* sp.) was the only tree that had everywhere lost its leaves, and in patches of this I failed to find fly, though searching carefully. This observation and the consideration that the acacias generally are not merely themselves deciduous, but, being for the most part low, must inevitably be defoliated by the fires, suggest that the distribution of the fly in August must be far patchier than it was as we found it.

The choice of a retreat would appear to lie between the granite kopjes, the thickets, and the borders of damp mbugas, streams and water-holes. It may be of interest to state my observations in this connection. The period covered is 10th May to 16th June.

*Granite Kopjes* (Pl. xv, fig. 2).—It was difficult to find tsetse in the bush of the granite kopjes even when they were abundant in the wooding immediately round, yet puparia, a small proportion of them full, could be found under most rocks, even to the summits of some of the kopjes searched, and natives frequently referred to the fondness of the flies for the rocks, saying: "There are few here, but many at the kopjes yonder."

The natives also stated that the kopjes are less scorched by the grass-fires than the country round them ; and it was obvious from the relative lack of grass on most of them, that resulted from the fact that scrub filled the interstices between the rocks, that this must be the case, and probable that (as the natives stated further) the kopjes would tend to retain leaf when their surroundings were already leafless.

*Thickets* (Pl. xiii, fig. 2).—In general the fly was found in its largest numbers in mgongwa acacias interspersed with considerable but broken thicket undergrowth, and in mhali wooding, chiefly where there were thickets of a type that would have attracted *pallidipes*. The ihusi, mkwata and mhali (the first two unidentified botanically) were stated by the natives not to lose leaf readily, the mgongwa and ilula coming next. The bridge of bush between the Sansui mbuga and the cleared country of Luguru, composed largely of ilula and other Mimoseae with overhead mhali (*A. spirocarpa*), was all very leafless on 1st June with the exception of the ilula, and in the latter, light though it was, occasional tsetses, mostly males, were taken.

Not all thickets or all mhali were equally suitable. To judge both from native accounts and from my own results, the fly was nearly absent from the strip of unusually fine spreading mhali acacias (with and without heavy thickets that sheltered some *brevipalpis*) that follows the lake submarginally between the Mbarangeti and the Rowana, though it occurs in drier, thinner bush on the mbuga side of the strip.

On the other hand, the worst place in Itilima was stated to be near Zagayu on the right of the road to Luguru—a jumble of granite kopjes, small vleis and thickish bush.

The following extract is from my road notes of 22nd May :—

"4 p.m. Entering broad-leaved bush dominated by mgongwa and numerous thickets—*Commiphora, Combretum, Albizzia, Markhamia*, some *Odina*. Numerous tsetses.

"Further, on down slope, drier bush—scrub patches with kinumburi, some ilula, a great tendency to leaflessness, especially in *Commiphora*. No bigger trees or mgongwa. *No tsetses.*

"Then much *Odina*, practically leafless. Two flies only, taken at thickets in between with dense *Euphorbia*.

"4.30. Narrow green vlei and pool with lilies, surrounded with tall green grass and overhung by dense mwotobarasi bushes. Beyond it simply *Odina* and light ilula. Took great numbers at the pool."

*Water-holes and Swamps*.—On three occasions in the Simiyu area, working with the cattle, I sustained considerable attacks on arriving at water-holes. Two of these were beside bushy granite kopjes, but themselves in lightly infested bush (in one case mere brakes of a shrubby *Combretum*), and the third has just been described. In general, we seemed able to count on an attack, large or small, on reaching a water-hole (as opposed to a pool in a stream).

The edges of open swamps bordered by numerous ilula acacias, and for the most part now dry, were sometimes points of attack by several flies together, or (if we stood) a succession of them. Such points were regarded as bad by the natives, who said of the seasonal connection between the fly and the ilula (and mkwata), "The fly never leaves them." I failed to find at these places the visible fly-concentrations on grass and paths that I found in the case of typical *morsitans* in similar situations in Portuguese East Africa—though Turnbull one day sustained an extraordinarily heavy attack at a spot in a small open vlei near kopjes in which I failed to obtain any tsetse on a subsequent special visit—but they were definitely regarded by the natives as bad. The same, it may be added, applies to *G. morsitans*. Vleis lined with ilula that Major Murray and myself had traversed in motoring from Tabora to Kahama had provided fairly heavy onslaughts by the latter fly. This was on 3rd May, when the surrounding bush was still full of leaf.

When thickets such as I have described as of the *pallidipes* type bounded a swamp, the presence of more or less numerous tsetse (*G. swynnertoni*) was nearly certain. Such a spot, where there was a severe onslaught by tsetses, is shown in fig. 2 of Plate xiii.

*Rivers*.—It is curious that in the infected area we failed to take this fly at all definitely in any of the formations which I have described above as "fringing." These were very thoroughly searched where found in order to make sure of the presence or absence of *palpalis*, *brevipalpis*, or *austeni*. The incriminated fly was not even taken in the more open mgu acacia formation prominent on the Duma and lower Simiyu, except as individuals that had followed us in, yet was present in some numbers just outside. *Pangonia*, on the other hand, was particularly abundant in such places.

It is likely enough that the dry season and the fires may drive the fly to the very spots from which we found it to be nearly absent—these fringing formations and the kopjes. Dr. Maclean found on 12th June many more flies on the streams in Msanza Mdogo than between them, and this may have been the beginning of a concentration. Manangwa Masalu, a headman who accompanied me northwards from Nasa to Kalemera in Msanza Mdogo, informed me that the bush on the small dry streams we crossed here was also, a little later, a concentrating-place for this tsetse. It was composed of *Acacia spirocarpa*, some *Albizzia brachycalyx*, some tamarinds and dense thicket of *Grewia* and other genera.

Fly was taken also at the Mbarangeti and Rowana fords—that is, in secondary fringing forest sandwiched between great open mbugas—by both parties which preceded me, each travelling by the main road. My personal party, which met the Mbarangeti lower and followed the Rowana up from its mouth, searching it slowly and carefully and taking numerous *brevipalpis*, but striking off before reaching the main road, found none. This difference in result was explained, I am inclined to think, by a previous observation on the little Gudama stream.

## IX.—An Apparent Method of Concentration.

In the observation just referred to, on the Gudama, Turnbull and I took several flies in a stream-bed thicket at a ford, yet I could find none in similar thickets in the same stream bed anywhere away from the ford, in spite of stays of half an hour in each place tested. In this instance, at the ford, we first took five females fairly

rapidly, then nothing for a long time—till a party of women passed through. On their arrival we at once took a male and two females that had presumably dismounted from them. Two, which definitely came on a messenger, were taken at one of the other thickets.

Meantime two pairs of natives with cattle were kept working up and down, on each side of the stream. Between them they took only one fly, a female, and that was at the ford. The preponderance of females may have resulted from a greater readiness on the part of this sex to dismount at the shadiest places. The conditions for pupae seemed ideal, yet a thorough search by a number of natives revealed none at all.

It is interesting to compare these results with my similar observations in Portuguese East Africa (Bull. Ent. Res., xi)—*morsitans* leaving us at the shadier wooding beside streams rather than in the open bush when the latter was losing leaf (p. 370), *brevipalpis* waiting similarly till suitable cover was reached (p. 357), and *morsitans* usually dismounting on reaching one of its own concentrations (p. 357).

In these observations generally we would appear to see the *modus operandi* of concentration, taking place in a diffuse manner even when the leaves are on the trees, but becoming marked, as a matter of course, when the suitable dismounting places become few and far between.

## X.—The Feeding Habits and Sex Proportions of the Fly.

I have referred to the fact that we found puparia freely under the large rocks of granite kopjes, even to their summits. These were on several occasions in close association with much dung of rock-rabbits (*Hyrax*). It seems most likely that these animals, abundant and sometimes conspicuous in the spots in which such large numbers of puparia were found, contribute to the sustenance of the fly, and certain that baboons must do so very largely indeed. I have myself found tsetses on baboons that I have shot in Tanganyika Territory, and been beset by tsetses on arriving at a spot from which I had dislodged a troop; and the Sultan of Itilima informed me that cattle-owners particularly disliked the incursions of baboons into fields in the margins of the cattle-grazing, as they commonly brought tsetse with them and cases of trypanosomiasis followed sometimes amongst the cattle. This statement bore out what was told me by the natives in Portuguese East Africa (Bull. Ent. Res., xi, p. 336).

Of the game animals—three zebra, six topi, six impala, two Coke's hartebeest and one roan antelope—shot on this safari, all but four were shot in mbugas, and tsetse were found on and about none of those thus killed. Of the four shot in bush, one (a zebra) was seen stamping and driving away flies before it was shot. Two flies were taken on an impala, and the roan and the kongoni showed none. The blood of these animals was examined, and gave negative results. They were too few, in any case.

The fly is a particularly surreptitious and (it would seem) gentle biter, for in the case of no tsetse have I seen so many successful full feeds on man. Again, in the Simiyu area it was the rule to take nearly or quite as many females as males, and the former often preponderated remarkably in particular places or attacks. This seemed to indicate a condition of hunger for man, had it not been that the females often travelled on us, like males, before feeding.

That this was, nevertheless, the correct explanation was shown somewhat later by a little definite experimentation at Ngasamo and Nasa, where in places where game or baboons were present in fair numbers the males far exceeded the females, while in pieces of bush that were being neglected by animals the female proportion was higher. In one experiment catchers who kept entirely in the main bush caught a great excess of males, while others who kept outside it in a mbuga in which were villages and a dearth of animals took, at a tongue of bush extending into the mbuga,

an excess of females. A complicating factor in such experiments was suggested by the fact that on several occasions in the Simiyu area it seemed that females were merely slower to attack than males. Thus in one case the first six flies were all males, but continuing to stand in the same place, our final bag was 11 males and 9 females. A marked excess of males became the rule after we had, at Ngasamo, passed out into the country of unimpeded movement of game. The grass was unburned in this area also, so that it was no difficulty connected with this that caused the flies to be more eager for food in the enclosed area than here.

A striking point about this fly was that it showed no appreciable preference for cattle as against man. My fly-boys also remarked with surprise on this contrast with all their previous experience. On several occasions when I was present the initial attack was on the cattle ; the fly then spreading from them to the men around and being mostly caught on the latter. On numerous occasions the natives actually catching at the cattle had no flies on them, while the cattle and the men five or six yards away were attacked, so that it was likely that the cattle acted as some protection to the natives actually working with them ; but this, and the possibility that the cattle did tend to induce more flies to leave the bush in the first instance, is the most that can be said, and the tsetse boys themselves considered that the fly liked man better. I was myself much reminded during these observations of my experiments on birds. These, when hungry enough, made no choice between insect and insect when laid down together, but took them as they came, the most "nauseous" species as readily as the more "palatable," except that they preferred the largest.

About Ngasamo, in spots where game was present, boys working with cattle brought in nearly the same large proportion of males as boys working without.

In general, I am inclined to regard this tsetse as having become, under the local conditions, an unusually dangerous fly to man. Mr. G. G. Griffiths also testifies to the savageness of its attacks in the Chinyanga fly-belt.

## XI.—Breeding-places of the Fly.

The high grass everywhere made it difficult to find logs, but in the thickets (mainly of a xerophilous type and characterised by *Sanseviera*) a considerable number of puparia were found under leaning trunks or at the bases of standing trees (especially *Albizzia hypoleuca*, Pl. xvi, fig. 1), as well as under woody scrub and the heavy coils of lianas. Most were empty, as on the granite kopjes. In its apparent partiality for thickets as a place of deposition the fly would appear to resemble *pallidipes* and differ from typical *morsitans*, for, in the west of the territory at any rate, few *morsitans* pupae but many *pallidipes* are found in these thickets, while under the logs in the grass outside them the proportions are reversed.

However, even the thickets were by no means more productive of result than the granite rocks. Single great boulders standing out from the base of a kopje would often be found to shelter puparia if they had even a slightly over-leaning side, and in dark places between cleft rocks, or under rocks strongly shelving, the puparia were sometimes most numerous, in sand or vegetable debris (Pl. xvi, fig. 2).

In one place they were found in numbers where this layer was a mere half-inch thick on the surface of an underlying rock. In another, what amounted to a cave sheltered both puparia and numerous Argasid ticks (*Ornithodorus*), though villages which had been near had been abandoned some years before. Under single rocks near Ngasamo as many as 300 and 400 puparia were taken. The conditions were always dry, and in some cases ant-lion pits were present also. In the case of the log shown in Pl. xvii, fig. 2, no shade at all was present. This I have found to be not infrequent in the case of *G. morsitans*. Puparia were also taken immediately round individual sleeping-sickness villages.

## XII.—The Following-distance of Female Flies.

The length of distance that a female tsetse will "follow," travelling on man or on animals, is a most important question in relation to the possibility of checking the advance of a fly-belt by means of a barrier clearing.

In my past experiments (with cattle and man and using *brevipalpis* and *pallidipes*) 820 yards was the greatest distance covered by any female fly. It was obvious from an early date that the present fly was behaving quite differently, and that considerable "followings" by females were taking place.

I took the first opportunity to test this view by awaiting my carriers near the opposite side of a completely open mbuga and catching and sexing the flies on them when they had been travelling for twelve minutes (half a mile) in the mbuga. Six of the flies were females—resting on the men's backs, not feeding—and ten were males.

Again, at Zagayu, with Mr. Tully's help, marked females were tried, and I myself saw followings of a mile and a quarter on walkers and (one marked female) on a carried cloth screen. Mr. Tully obtained a considerably longer following by using his bicycle for part of the way, but it was known already that female *G. morsitans*, at any rate, will travel for great distances on fast-moving cars and bicycles.

The females travelled quietly, without (so far as I saw) constantly flying off the walker's back and returning to it as did the males, and, apart from size and colour, it seemed possible to distinguish the sexes in this way. Also they usually settled down to feed in the end, which the males did not, and then left their carrier. It may have been a coincidence, or it may not, that the females of the Zagayu experiments tended to begin to feed as the rest-house and huts, the first conspicuous object since leaving the bush, were approached.

The full distance that will be travelled has yet to be ascertained, but a barrier of a mile and a half and probably very much more would have to be cleared to obviate the likelihood of females crossing it, even on natives—at any rate when the fly was specially feeding on natives, as it seemed to be doing here. The experiment was useful also as indicating the special danger of leaving patches of bush standing near dwellings or segregation camps within following range.

A point best mentioned here, though it follows naturally on the concluding remarks of Section X (p. 332), is that my observations on this safari tended to convince me finally that while many tsetses leave a party entering open ground, those that are once carried well out into unsuitable country do not readily leave their carriers till cover is once more reached. The conclusion extended to the female of the present species, and is of importance in relation to the idea of a barrier clearing.

## XIII.—Distance of Attack and Protection of Roads.

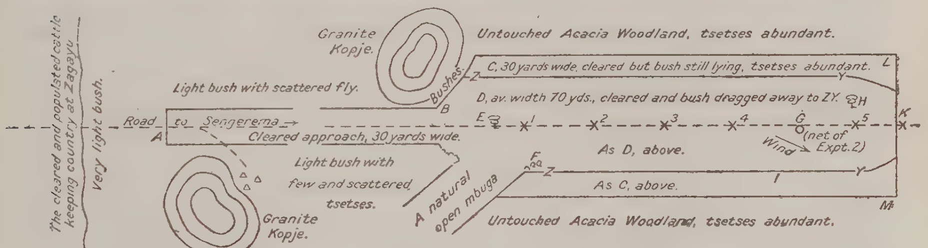
The provision of cleared high roads at the points where these are most required was one of the most urgently needed measures for the protection of the population from the infected fly. Experiments were therefore attempted with the object of ascertaining the necessary width of clearing. In order that the work should not be wasted and that no additional natives should be exposed to possible infection, they were carried out on a piece of road (Zagayu to Sengerema) that was about to be cleared by these people in any case as part of the scheme of control.

*Experiment I.—Range of Attack across Cleared Ground.*—It was planned to clear first to 50 yards on each side of the road and test, then to increase the width and test again, and so on till a conclusion should be reached. Owing to the miserable native tools it was impossible to complete this in the time at my disposal, and the actual experiment was as shown in the text figure.

From A to B, about 900 yards through lightly infested bushes, was cleared to a width of 30 yards to minimise the chance of picking up tsetses in travelling to the

experiment with numbers of natives and cattle. It proved useful, and an inspection took place at B to remove all remaining tsetse (I think one only was present). From B to K, the actual experiment, was 600 yards in length, a stretch of road on which tsetses had been abundant. The width of complete clearing (D) varied from 53 to 80 yards. E and H were solitary large acacias left uncut, each with a good clear stem. G was a large, white, conspicuous mosquito net in use for the second experiment I shall describe.

From two to three natives and two cattle were placed at each station shown above (E, G, H, K, and X, X, X). There were seven pairs in all, the last pair working X⁵, H and afterwards K. E and G cattle stayed where they were, but the X's occasionally moved to each other up and down the road or took up intermediate stations on it, some of them with a clear view to the bush owing to the grass having been destroyed by the dragging away of trees and shrubs, others in long grass.




*Result.*—The results at the stations varied in the most interesting manner. At E, a conspicuous mgongwa acacia just 80 yards from the nearest bushes (of the granite kopje on the one side and a few slightly out-jutting acacias at F on the other), flies of both sexes were taken steadily all day to the total number of 77. Yet $X^1$ close by, and sometimes moved closer, saw not one.

The catchers stationed at G, the conspicuous white mosquito net, also took flies steadily all day, as did acacia H and (in much greater numbers) post K on the road where it left the clearing. Yet $X^2$, $X^3$ and $X^4$ took none at all when stationed in long grass and only half a dozen in all when in view of the bush.

The fact that natives were working in the bush (though in two compact and localised parties) complicated the experiment by rendering it possible that they drew off or fed a number of flies that might otherwise have been attracted to the road, and the line of dragged-off trees (X to Y), while containing numerous tsetse, was obstructive to vision from the bush behind, but it seems likely even from this incomplete experiment :—

(1) That a clearing even of 70 yards on each side of a road would afford great protection when the grass is long, but is likely to be much less useful when it is short.

(2) That the period of long grass is probably for the fly a period of relative difficulty in finding food-animals. Here we have some slight experimental confirmation of a point to which Fiske and Duke have drawn attention.

(3) That both sexes of this tsetse range to some extent, flying to conspicuous objects such as isolated trees and (probably) rocks at a distance of not less than 80 yards in cleared country, perhaps much more. It follows from this that no trees, however clean-stemmed, must be left in a road-clearing. Also that the high, black-green euphorbia hedges that make the villages so conspicuous may be a disadvantage when the village is within one or two hundred yards of bush.

*Experiment II. Range of Perception.*—A wide mosquito net was erected at E and more than 300 flies turned into it, of both sexes. The idea was to pass a large number of men and cattle to windward and note up to what distance the tsetses would fly to that side of the net on receiving their scent.

Difficulty occurred owing to the fact that the tsetses persisted in congregating on the windward side of the net. Apparent reactions occurred at all distances from 30 to 150 yards when the party passed exactly to windward of the fly and no reaction at 200 yards, but I am not describing the experiment in detail, as I do not regard it as reliable, and I had, unfortunately, no opportunity of repeating it.

Against the indication that the fly attacks from far may be set the conditions at some of the watering-places of native cattle ; for example, right up against tsetse-infested bush at Mtukuza and in the mbuga just north of Mount Sansui, though in each case with a sixty-yard fringe of open mgu trees with only occasional flies between the water and the mhali-and-thicket that really contained the tsetse. The natives stated that they dare not traverse this further distance with their cattle.

*Distance of Attack through Bush.*—Yet another set of observations suggested that attack may take place from quite a distance in bush, at any rate under the conditions of hunger apparently prevailing here. In my previous experiences of tsetses the few men at the head of the safari have had nearly all the flies. This by no means happened with the present tsetse, for on many occasions the middle or even the hindmost men had more tsetses than the leaders, and it seemed very much as though the flies were coming to us from considerable distances and, arriving late, swerved and followed up, alighting on the first man they reached. This was suggested also by the fact that in country in which we picked up merely occasional flies we often, by standing for some time, drew in tsetse after tsetse until the total for that one spot reached quite a large figure. All this was in bush, not mbuga, and there was nothing, therefore, to indicate what the distance might have been. On one occasion when I was standing in a mbuga 150 yards from the nearest bush two flies came to me, but there were a few small bushes in the mbuga that may have harboured them.

## XIV.—Miscellaneous Notes.

### 1. Settling Habits.

The fly resembles *G. morsitans* in the fact that individuals move along in front of the traveller, settling before him on the road. In open spaces the flies on his back tend, when he halts, to distribute themselves on the ground about him.

### 2. Relation of Game and Cattle.

At the Mtukuza mbuga, two miles broad by possibly twice as many in length, which we worked to get an idea of the position at these natural open spaces haunted by game, occasional flies were taken up to 500 yards out in the ilula-clumps—more or less connected by a few bushes and small clumps with the main bush containing fly—but none at all in the open, though we put up topis, zebra and roan antelopes, and at once worked along, men and cattle, in their tracks. No puparia could be found at the water-hole, at which the game drank, in a small patch of acacia that included one or two large and shady trees. In this mbuga there are four small herds of cattle, living safely, their owners state, and those I saw certainly looking well, in close contact with the game and much attacked sometimes by Tabanids. The game is regarded as coming out and living—and sleeping—in the mbuga to escape the attentions of the tsetse in the bush, and the tsetses are said not to follow them into the mbuga unless in one and twos, as they "fear the hot sun." The game retires to the shade of the clumps in the heat of the day.

From this and other evidence I judge that the danger to cattle from game wandering on to its pasture out of fly-infested bush will not be great, provided that the clumps of bush on the pasture are cleared or the cattle kept away from them.

While at Mtukuza I was told of two fly-surrounded mbugas near the Duma, at one of which (Inyamageni, stated to be much smaller than Mtukuza) cattle, it was alleged, had been kept in safety for many years ; while at the other (Magerani) small losses were always taking place. At Manangwa Masalu's, on the Nasa littoral,

cattle were being farmed in a mere mile-wide strip, some of it going back to bush as the result of a reduction in the number of cattle. The position between the Mbarangeti and Rowana is still more curious, for here a very narrow clear strip exists between the Lake and a submarginal strip of fine mhali wooding, sheltering thickets in which *brevipalpis* is present and in which occasional *swynnertoni* appear. Yet cattle are kept there permanently, it is said, without loss, and looked well.

Instances occur also elsewhere in the territory of fairly successful cattle-keeping in diminutive, fly-surrounded open spaces. Safe water, avoidance of too close approach to the bush and avoidance of much-frequented paths and villages would seem to suffice ; and it seems to follow from this also that the fly does not venture uncarried into open country unless to conspicuous objects within a limited range.

### 3. Banishment of Tsetse by Partial Clearing.

At Kilalo I saw the interesting phenomenon of the riddance of fly by *partial* clearing. Small areas of wooding were still present, but they were mostly in the valleys and cut off from each other by cultivated hill-tops and upper slopes. Several herds of cattle were present, and only occasional tsetses were said to be met with. It was said that twelve years ago the position with regard to the tsetse over most of the area was the reverse of what it is now. That is, the cultivated fields instead of the bush patches were the islands, and tsetses still inhabited this bush, which was also then more widely connected with the main infested wooding. In Tshasama's country also small areas of bush cut off from the main areas had become free of tsetse. At Kilalo *G. swynnertoni* is concerned, at Tshasama's *G. morsitans*.

### 4. Test of a Tsetsefuge.

Garlic, suggested by me previously (Bull. Ent. Res., xi, p. 380), was tested for me very fully on cattle by Mr. Tully, and proved a failure. An interesting point that came out well in the watching of the cattle used on this expedition and to which Mr. Tully drew attention was that, quite apart from considerations of colour, individual cattle are far more attacked by tsetses than are others.

### 5. Protection against Bites.

I dressed my more permanent tsetse-catchers in white clothing with long trousers. It was soon remarked by themselves and their companions that they drew few flies, and it was a matter of daily observation, when on the march, that dark colours and khaki attracted far more flies than white. Long trousers in themselves are not an absolute protection for the legs. I was bitten inside my helmet, through my clothes, and once by a fly that, in the tent at dusk, introduced itself into my trousers at the ankle and bit me inside the thigh. Again, white clothing becomes less protective when no alternative is present for the flies to go to.

A veil was tested on one or two occasions, but discarded as obscuring vision. It was a protection, but a discomfort.

## XV.—The Known Infected Area and the Tsetse apparently responsible for the Spread of the Infection.

The infected section of the Usukuma fly-belt, in so far as it was known at the time of my departure, was bounded on its west and south-west by the western margin of the tsetse-infested acacia woodland area from Nyalikungu to Nung-hu, and on its east by the settled Zagayu-Luguru-Uhiro arc, with some infected villages outside of it. On the north it extended across to the Duma and crossed it, the Ngasamo-Kilalo-Nasa road being roughly the boundary here. An isolated small outbreak was reported from Bukumi just south of Ikoma, but I judge from an incidental reference in a letter that this proved not to be trypanosomiasis.

The infected section thus includes a considerable length of each of the two rivers mentioned and this, with the distribution of some of the cases, gave rise to the suspicion that the infection might be carried by *G. palpalis*. The people did much fishing, and it was possible that, meeting at the rivers in the course of this occupation, they were much bitten there by tsetses and infected. Certainly some small focus of this fly may exist on some reach of one or other river that has been missed by Maclean's search and mine, but this is unlikely, and it could not in any case account for the position. The villages in the tract between the rivers and many miles from either were infected with the rest, and the history of the epidemic, as given by the natives, showed that it travelled from village to village irrespective of any relation to rivers. It would also not account for the infection of women and children at a great distance from the rivers, and still less for the case of the young man I shall refer to below. He was blind, and there was every reason to credit the statement made of him that he had never previously left the neighbourhood, which was a considerable number of miles from the Simiyu.

Experimental evidence was still lacking when I left, but the circumstantial evidence was strong in favour of the view that *G. swynnertoni* was the responsible species. It was, as I have said, taken by my fly-boys in thousands in the paths and villages of the infected section, and was the only species of *Glossina* that could be found there at all.

## XVI.—Types of Sleeping Sickness Villages.

*Village completely in the Bush.*—A small triangle formed by native paths through high weeds. At each of two of its corners a hut, at the third two. A diminutive and dirty open space before each hut and a shade-tree at two of them. The general thorn forest—mgongwa and mhali acacias, with some *Albizzia hypoleuca* and much *Commiphora* thicket—extending right up to two sides of the triangle. The third side abutting on a limited open space of grass and weeds representing old cultivation, itself surrounded by the bush. A path leading through this and then through mgongwa-with-thicket wooding, past a granite kopje, in which we found puparia, to a water-hole in the bush. Another bush-path leading to the main piece of cultivation some distance off in the bush in another direction.

Fly fairly abundant in the thorn-bush near, but less so than in the village. Here it seemed concentrated and greatly at home. An old woman who appeared was accompanied in all her movements and domestic duties by tsetses of which she took little notice. A dozen or more at a time would be perched on her leather garments and her skin. A number followed her into her hut and remained there. One of my fly-boys went in and captured six. About and between the huts we were much attended, and a few fed successfully. Unfortunately it did not at once strike me to keep this catch separate or count the flies, but, out of five boys, one that counted from the start captured 35, and from the very late moment at which I ordered a separate catch, over 70 were taken. The total will not have been less than 200. A few *Haematopota* and *Tabanus* were present also.

One of the solitary huts was deserted. The woman had died of sleeping sickness and her husband, the headman, had gone ; apparently it was not known whither, or whether he was infected. Of the four remaining inhabitants one man still well was away accompanying one of the others, a young man with sleeping sickness, to Dr. Maclean's nearest hospital ; the old woman has been mentioned, and a younger woman "had been ill with malali but was now better, and had gone some days before to visit in Igombe." I found her bed had just been slept in—a probable case of concealment.

There is only one thing to be done with the inhabitants of a village of this kind. They are attended in every occupation of the day by tsetses—in their village, inside their huts, going to water and hoeing their fields. Let one of them become infected,

and he is bound in the course of a four to eight months' illness to infect many hundreds of tsetses ; and the infection of his fellow-villagers and the neighbourhood generally is only a matter of time and possibly of a very short time. Evacuation is necessary.

*Village in a Mbuga.*—A more compact village of several huts, some of them surrounded by a tall euphorbia hedge, the whole much cleaner and less overgrown than the last, standing a quarter of a mile from the bush in an open grassy mbuga. Other euphorbia-circles in the mbuga, some of them still containing villages. The mbuga surrounded by tsetse-haunted thorn bush. The river, in which much fishing is done, not far away, and the village itself close to the borders of the better game country. One of the outermost of the infected villages.

My first visit was by moonlight and no tsetses were seen. On my second, with Dr. Maclean, two tsetses were caught in the village, perhaps carried in by ourselves. It was stated that sometimes many tsetses are carried in from the bush, and from one result of the clearing experiment described above, it would seem that occasional tsetses might range out from the bush to so conspicuous an object as a large, black-green euphorbia hedge. The conditions in the village itself, however, are not ideal for direct transmission.

Three people, perhaps four, had already died of sleeping sickness in this village, and four others were sick, one of whom had come there sick from another village. One of the four, a little girl, was dying, and died next day, but was replaced at the second visit by her brother, who showed symptoms sufficiently suspicious to warrant an injection. Visits to a neighbouring infected village (further from the game and in the bush) were regarded as the source of the infection.

It would probably take comparatively little clearing to protect the people of a village of this type (of which there are many) from tsetse, if only they would then keep to the cleared area and cleared paths ; but the bush is all round, the temptations of the river and the game at their door are too great, and they are too far away from everyone for supervision.

*Village in Cleared and Closely Settled Country.*—A lane, more than half a mile long, flanked on both sides by a tall euphorbia hedge ; small millet fields up against it on the outside. At intervals on either side small openings leading directly into sub-villages, which are themselves surrounded and sometimes subdivided by similar shady euphorbia hedges reinforced closely with dry thorn to make them impervious to cattle and goats. The whole standing in cleared and open country. Several cases of sleeping sickness present, and a number of deaths already. *Ornithodorus* ticks and mosquitos present, but the possibility of direct transmission through these negatived by the fact that except in one instance the cases were scattered, single members of families being infected and (except in the one instance) no hut-fellows. No tsetses could be found.

At its narrowest point the completely cleared country seemed to be half a mile wide, counting from the nearest end of the lane, itself nearly half a mile nearer than most of the cases. A large millet field belonging to the village then separated the grazed strip from country in which bush was beginning to grow up on the site of old occupation. In this was another village belonging to the same headman. There was much visiting between the two villages, one on each side of the millet and open ground, and tsetse were present in small numbers in the young scrub. A considerable distance farther on came the real thorn forest, with more numerous tsetse and an earlier infected village. The patients there had also been much visited by the members of the village I have described, and its infection was attributed to this, though the bush was visited also for firewood and building material, and doubtless for other purposes.

A few tsetses would be carried back on these occasions, but the scattered nature of the cases, referred to already, suggests that these tsetses carried into the villages

would have been a less important factor here than in (at least) the first village type I described, and that the victims probably became infected independently in visiting the area containing infected tsetses. It was hardly a "village epidemic."

The distance from the bush is here probably sufficient for future purposes in view of the fact that the country about is cleared and settled and supervisable, and that the highly infective bush villages will have been removed. The further remedy lies in the prevention of visits to the bush, the abandonment of fields that lie in the margin of the tsetse country or wide and complete clearing beyond them, and, possibly, the cutting back of the euphorbia hedge to a height at which it will still be serviceable for cattle but will not give shade.

Probably many of the villages to be evacuated will afterwards occupy the position of this village in relation to the bush, owing to congestion further in, and the prevention of the natives from visiting the bush is, temporarily, a matter of importance.

## XVII.—Duration and Course of the Infection.

### Possible Date and Original Locality.

There was a regular passage of natives for trading purposes between the now infected area and the Mori, Shirati and even Kavirondo before the war—that is, with areas involved in the original great *gambiense* outbreak—but the evidence to the time of my leaving Musoma seemed to place the beginnings of the Simiyu outbreak at a later date. The natives everywhere, as well as Messrs. Zimmerman and Buttler, of the Ngasamo Mine, stated that they were certain that the disease was not present before the war. Manangwa Salim, of Basheshi, who was with Von Lettow till the armistice, told me that subsequently to his return there was increasing talk of cases of "safula," or ankylostomiasis, for which the natives till lately mistook it, though the first cases of the present disease that he is himself sure of were observed three years ago at Igombe, where last year deaths were already particularly numerous.

Questioning of the chiefs elicited references to alleged early cases. Thus a Msikuma disbanded at the end of the war after serving first the Germans, then the British, is said to have then come straight to Luguru already showing sleeping sickness symptoms and to have died. He may have contracted infection on his way from Mwanza. At the beginning of 1919 a man from Kilehiji, four miles north of Luguru, on the edge of the bush, was taken to hospital in Mwanza by Sultan Mwanilanga with symptoms that, according to the Sultan, were completely identical with those of the present outbreak. The disease, however, does not seem to have been recognised as sleeping sickness in Mwanza, where he died shortly afterwards, after an illness that had lasted in all eight months. A man named (or from ?) Yikiji was said at Luguru to have contracted the disease four years ago and died two years later. Sultan Tobias, of Usmao, about fifty of whose people have died this and last year, spoke of the death last year, with sleeping sickness symptoms, of a woman who had been ill for three years. Several natives—and this seems much more important—stated that the first cases of what was then called "safula" (hookworm), but is now recognised as "malali" (trypanosomiasis), coincided with the end of the great famine of 1918.

Naturally, native diagnosis cannot be relied on, and some of these may not have been cases of trypanosomiasis, but the more prominent symptoms—the oedematous feet, dry skin, large appetite, distended stomach and growing emaciation—were a combination that is readily remarked and was always quoted, so that if no evidence to the contrary has been obtained since I left, the epidemic would appear quite likely to have started from five to six years ago. That it had already started at the beginning of 1918 is shown by the one really reliable piece of evidence available. Dr. A. Balfour tells me that in Mwanza, on 2nd April 1918, he found unusual numbers of trypanosomes—as numerous nearly as the red cells—in a slide made from the blood of a patient from Usmao who had died shortly before, which was submitted to him for confirmation by Capt. J. Currie.

Except for an old man who insisted that cases occurred even earlier in Usmao—just across the Simiyu from Igombe—natives everywhere regarded Igombe, near the Simiyu, as an early focus of the disease—" The first news came from Igombe " —and they traced its passage thence from village to village, naming each, until it came to their own neighbourhood, when their detailed account of its local course was simply a replica of the example I shall give below. I am rather impressed by the possibility that the infection occurred first in Usmao because the infested wooding there is on the border of a well populated piece of country. There were many people near its margins to come into contact with the tsetse, and, there being many people, the game would have been particularly heavily reduced, so that the tsetse might have been brought into exceptional dependence on man. It seems possible (and the special intensity of the infection may favour this view) that Capt. Currie's case (from Usmao) was amongst the earliest that occurred. The exact locality is, however, a mere matter of detail, for game had been greatly reduced throughout the area between Usmao and the Duma.

**Mode of Spread of the Outbreak.**

It was always easy to trace a sequence between any case and preceding cases. Thus a woman sick with " malali " came from Ndagalo and stayed at two villages near Nyasambi, at the second of which she died. Her presence was closely followed by cases at each village, and the people from neighbouring villages who regularly visited and sat with the sick, and attended the mourning, fell sick next and introduced the disease into their own villages, in which further cases then occurred. One of these cases taken to a clean village to be nursed introduced the disease there, and the occurrence of a beer-drink at that village, with many tsetses present, passed the disease on farther. This was the story everywhere.

Going to see the sick, and taking the sick in, seem to have been the commonest sources of infection recognised by the natives. One woman sick with " malali " in the Igombe area was said to have wandered for long from village to village, more or less demented, and at last to have died in the bush, having probably first infected numbers of tsetses and several villages. Business claimed its victims ; a woman who went to a sick village in a neighbouring Sultanate to inspect some ground-nuts contracted the disease. After her return six other persons got it, and, of the seven, six were dead at the time of my visit to her village. Going to work—or stay—in Sengerema or Igombe was said to have brought the infection to several places to the south and west of them, and at least some of the Sengerema infections were said to have been due to the fact that many Igombe people, getting frightened, shifted over to that Sultanate.

Two native doctors at Turasi, practising among the victims, were stated to have contracted the infection themselves and died. Their methods were long series of incisions down the inside of the legs (of which we saw examples), massage and medicine by mouth.

Contact with the sick in villages was thus fully recognised by the natives as a mode of infection, though they had not realised the part played by the fly. In addition to these infections in villages there must have been many infected tsetses travelling with the natives on the paths and, if cyclical infection plays its part, present in the bush also.

Whenever a narrative came to a patient who migrated to a village well inside open country it stopped—" No one else got sick there."

Nevertheless, an exceptional number of cases had occurred apparently along the margins of the populated areas, such as that of the cleared strip of Luguru ; no doubt, chiefly because it was here that the largest number of people were in contact with the fly. It may very well have been due also to the fact that game was scarcest there and the fly most dependent on man.

There was no indication of new and independent infections. Every case appeared traceable to contact with sick persons in the presence of tsetses. Man seemed now the sole reservoir, however the first infection arose.

The outbreak seemed already to have halted in its northward course at the time of our visit. Yet the northern barrier against the game, with which the check coincided, was, unlike the eastern, by no means of a nature to check the disease. Concealment (of which we obtained no evidence) and areas of more open woodland with fewer tsetses were two possible explanations of the fact that the disease had not appeared in villages into which, on the analogy of its previous history, it might already have been carried again and again ; but it was strange that cases should be concealed more here than elsewhere. The check did, however, coincide with two other changes : game was present in fair numbers and baboons were numerous, and (a consequence of this) an equality in the sexes of the tsetse, with local excesses of females, had been succeeded by a general great excess of males. In any case (*cf.* the footnote on p. 351, and the instance of the Luangwa valley) there is no reason why odd cases should not occur in game country, and these will doubtless yet be found.

## XVIII.—The Facilities for Direct Transmission.

### Comparison with the Conditions under which Direct Transmission spreads Nagana.

For the spread of trypanosomiasis in a herd of cattle by means of direct transmission a heavy infestation by the flies appears necessary (as in the great October–December outburst of Tabanidae), combined with close contact amongst the cattle ; and the result, as I have seen myself, varies from no or few infections to heavy infection. Chambers records (Vet. Review, i, 1917, p. 222) an instance in which 280 cattle out of 300 died as a result of the introduction of three infected beasts in tsetse-free country.

With the flies few or the temperature low it may be that the cattle resist the occasional trypanosomes injected, but under the October–December conditions, with hundreds of flies, constantly disturbed, to every animal, individual beasts, few or many, may even through dint of sheer repeated biting receive some approach to the number of trypanosomes that, after cyclical development, fill the proboscis of a tsetse.

In view of Duke's most illuminating suggestion (Parasitology, xi, 31st Oct., 1919) that direct transmission by *G. palpalis* may play a very important rôle in human epidemic trypanosomiasis of the *gambiense* type, it is interesting to enquire whether the conditions under which mechanical transmission produces outbreaks in herds of cattle ever exist for man in relation to infection that is carried by flies of the *morsitans* group.

The Tabanidae may, I think, be ruled out at once as an important factor. They attack man but seldom in anything approaching the numbers in which tsetses very ordinarily come to him, and they also relatively seldom succeed in sucking blood. The same, in somewhat less degree, applies to *Stomoxys*.

On the other hand, the tsetses *G. morsitans* and *G. swynnertoni* do attack man—seldom, unless he is on a bicycle or a car, quite in the numbers in which the October Tabanids swarm on cattle, yet often in very considerable numbers indeed. They have fewer individuals among whom to divide their attentions than have the Tabanids in the cattle-kraal, and they are individually exceedingly persistent, so that even half a dozen of them, not feeding seriously or often driven off, might transfer many trypanosomes directly in the course of half an hour from a sick person to a friend sitting chatting beside him, or as between the members of a party travelling. Tsetses, again, tend to be present in greater or less numbers for many more months than the Tabanidae, and the fact that an infected person takes a few months to die will bridge any ordinary gap.

**Conditions under which Tsetses of the *morsitans* Group concentrate on Man.**

Observations here and elsewhere in the territory show that concentrations, large or small, of tsetses that are indicated by the proportion of the sexes to be concentrating their attention on man are caused by the relative absence of game and by nothing else. With game absent, they may take place at villages, particularly perhaps near primary or secondary centres, and along paths, on travelling parties, and at the more suitable patches of bush crossed by the paths, as at water-holes, streams, and particular thickets and vleis; for at such places (as we have seen, p. 332) flies are apt to leave their carriers, at such places they tend to persist in smaller or greater numbers throughout the year, and at water-holes and streams the natives themselves (each party carrying in an accession of flies) break their journey to drink or cook their food or to rest, and sit with other natives who have preceded or followed or met them there, while all are bitten repeatedly by the same tsetses. In game country concentrations of the particular kind referred to do not take place, except very temporarily or incompletely. Thus tsetses may attach themselves specially to passing man for a week or two only, after a grass fire, or when, near the end of the long grass period, game is attracted away to early "burns." At the long grass season natives leave the paths less and so probably come into contact with far fewer tsetses, but those flies that once come to them may tend to remain on the paths and in the villages owing to the fact that, with the grass long, they will not easily detect other prey by sight. That they may detect them otherwise was suggested by the way a succession of tsetses would sometimes find their way to us singly, until a large number had collected, when we stood still for long in one place. I think that these minor types of concentration may be disregarded, except where actual sleeping sickness or conditions specially favourable to it (such as famine and game destruction) are present. Here they might act as accentuating factors. Most of the cases of sleeping sickness enumerated by natives were described as having taken place either "at hoeing time" (two months after grass-burning), or when the crops were sprouting (temperature rising and flies abundant), or at "Ramadhan" (the date of which, retrogressing each year, has probably travelled during this outbreak from September to May). It is interesting to note also that of the first two dates referred to, the first coincides with and the second shortly follows the usual climax of the beer-drinking season.

This brings me to the point that, whatever small part may be played by the game, no one who has observed the habits of the natives can well regard man as other than the chief or only reservoir in any human trypanosome infection. Sick natives—even very sick natives—spend much of their time outside the huts with children playing near them, women stamping grain or grinding and preparing food beside them, men sitting about (sometimes for hours) occupied or idling. People drop in from neighbouring villages or (particularly on a main road) pass through in travelling and—an important habit from South Africa to Tanganyika Territory —they stop, sit down with the inhabitants, and give their news and receive that of the locality over a platter of food that seems always ready for production and round which the men of the village also crowd, each person dipping in his hand in turn while the same tsetses bite all. This habit of stopping to exchange news —indulged in always, even on the open road—is one main factor. Another is the beer-drink, which, in great part, and in some tribes more than others, takes place outside the huts and in the day-time. Travellers tend to stop at a village in any case, but if a beer-drink should be taking place there or in a village near (and it can always be heard from a distance), they stop often for hours or for the period of its duration, which may be three days, and, crowded densely round the beer-pots, come into intimate and continuous contact with the population of all the villages round—invited wholesale to assist in the hoeing of his garden that has constituted the owner's object in brewing the beer. The same thing happens at the next village and the next, for the hoeing season (at and following which, according to the

above information from the natives, so many infections took place) is often simply a round of beer-drinks, with the same tsetses biting all partakers at each. Beer-drinking recrudesces later when the new crop is felt to be such a certainty as to justify the use for beer of the store-grain, gains force with the final harvesting of the crop (that is, in July), and shortly afterwards again attains its maximum intensity with the arrival of the hoeing season. In real famine there are no beer-drinks, but I have myself seen them become all the rage when the first crop after a famine or semi-famine was reaped. People then simply gave themselves over to them. And this, with infection well established through the aid of the famine, is the very time that is critical as regards its further spread in localities in which the tsetses are concentrating on man. A third meeting-place is the water-hole, at which members of many surrounding villages tend to congregate when drawing water, washing, or carrying out some parts of the process of preparing beer. Water-holes and fords on roads have been referred to as a factor elsewhere. A fourth important factor is the caravans, travelling closely in single file, with one member perhaps infected or the tsetses from an infected village they have passed through accompanying them. A fifth, important only on lakes and large rivers and usually unimportant as regards flies of the *morsitans* group, is one to which Duke has drawn attention—canoes and landing-places. Finally, there are such occupations as hoeing and threshing. Here, as at the beer-drinks and round the food-dish, the participators are crowded as closely as cattle in the cattle-kraal. The flies may be switched off frequently, but settle again at once on somebody, and a highly occupied man or woman, and particularly a drunk or fuddled person, takes little serious notice of them.

People who are not yet very sick take part in the ordinary occupations of the community. The very sick—except those in the last stages of weakness—spend, as I have said, much time in sitting or lying outside, near the other members of the village if they are present, being specially visited and sat with by their friends and relations of the surrounding villages and by passers-by, who are brought to see and discuss their symptoms and (in the Usukuma outbreak) to prod the oedematous parts. This last quaint point was volunteered by several of the natives I spoke to in the sleeping sickness area and appeared almost to be regarded by some of them as a cause of the infection. Also the sick take part in, or lie near, the crowded beer-drinks. And the tsetses, in an infested bush village, enter the huts. My experience, extending over more than twenty years, of the habits of the sick African in his home is concerned with other diseases than sleeping sickness, but I saw nothing amongst the relatively few sick I found still in their villages during my visit to make me regard sleeping sickness patients as an exception and heard much which showed that they were not, and I wish to lay particular stress on this usual relation of the sick to the well, and on the resulting fact that every case, through much of its course, of *rhodesiense*, as of *gambiense*, may form an important reservoir of the disease.

Famine vastly increases contact both within a given area and as between that area and those surrounding it. In the one considerable famine of my own experience even the decrepit and nearly dying struggled through the country trying to buy, beg or work for food, and inhabitants of villages from far around would meet at spots in which wild yams, mushrooms, certain wild vegetables or the fruits of *Uapaca* were specially to be found, and they might be seen sitting and digging together at the clumps of yams.

The concentration of the flies in the village I described first in Section XVI was somewhat heavier than at any other bush village I entered, and distinctly heavier than in the bush around, but it was sufficiently typical, and it is obvious that there was every possibility of direct transmission between the inhabitants, and between the sick and their visitors from neighbouring villages, who would often sit with them for hours ; and that the relations between man and tsetse were everywhere such that direct transmission might quite well have played an important part in this

epidemic. The danger of direct transmission of human trypanosomiasis is, as I saw clearly, by no means limited, however few the trypanosomes in the peripheral blood—and in some of the cases examined by Maclean while I was with him they were numerous—as, I understand, is the rule in infection with *T. rhodesiense*; and it seems easy to understand how, under conditions so favourable to intensive direct transmission, the pathogenicity of the trypanosome might mount rapidly and bring about the well-known special virulence of early cases, taking place before any diminution of the fly, recovery of the game, extension into areas in which game was to some extent present, or more orthodox attenuating factors came into play.

The presence of abundant mosquitos in the settled country, combined with the alleged absence there of infections, might seem an argument against mechanical transmission. On the other hand, I know of no cases or records from which it seems likely that mosquitos have transmitted nagana of cattle, and it is possible that for mechanical reasons, or (perhaps far-fetched) as a matter of temperature, the night-biting mosquitos that alone were present in number may be less efficient transmitters of trypanosomes than the tsetses and Tabanids or than the two day-biting genera of mosquitos (*Stegomyia* and *Mansonioides*) that I believe are especially suspected by French investigators.

A further criticism might be to the effect that the European rarely comes into the intimate contact with sick natives in the presence of tsetses that I have described, and wears clothes, yet cases of trypanosomiasis in Europeans are not infrequent. Against this it may be said that it is not argued that cyclical transmission is not also a factor (and, if the disease is purely human, a highly important one); and, in addition, the question of the relative susceptibility of the races has never been adequately studied. The aggregate sojourn of white men in sleeping sickness foci is infinitesimal compared with that of the natives, yet even where only a rare native becomes ill Europeans have contracted the disease, though their porters have apparently escaped.

## XIX.—The Relation of the Game to the Outbreak.

The oedema that was commonly present and the identity of the insect vector suggest that the infection was one of *T. rhodesiense*, and even the rather long duration of the cases that told against this view is explicable on the fact that the epidemic had already lasted some years; but a decision on the point was lacking when I left, and several theories were still tenable as to the origin of the outbreak.

### If the Trypanosome is *T. gambiense*.

It seemed to us at the time of our investigation quite probable that the outbreak had been initiated by some infected person or persons with the Belgian or British forces that collected here to attack Neumann in 1917 when he broke back from the south of the territory to Ikoma.

A portion of this force, which included numerous carriers from Uganda who accompanied the Belgians, was landed at points nearer to Ikoma. Another portion was stated definitely by the chiefs and other natives to have passed through and camped in the villages of Igombe, Luguru and other parts of the country now infected "at the time of the ripening of the crops," and further contact with the inhabitants was established through the fact that the latter also were impressed as carriers and marched with the imported carriers.

On the other hand, the disease may have lingered unknown in some spot in our own territory since the great epidemic on the Victoria Nyanza. There was much movement of the Wasukuma people in 1917 and 1918, as I shall describe below; and this, or the wandering of infected individuals from elsewhere, may have brought them in contact with infection.

The disease has continued to exist in Kavirondo ever since the great outbreak on the Lake. A report by Dr. Johnston, dated 5th May 1922, states that in middle Kavirondo a case or two is present in practically every location, though the majority are in the Lake shore areas, and I was told by himself and others that the position was certainly not better in south Kavirondo. Infection thence represents a third alternative.

Should our trypanosome be *gambiense*, actual or convertible into *rhodesiense*, the fact that the disease can be freely carried by a fly of the *morsitans* group would turn the position in Kavirondo, if it should continue, into a menace to the great territories to its south.

**If the Parasite is** *T. rhodesiense.*

In this case, which seems more likely, three further theories of origin arise: (*a*) that it was introduced into Usukuma as a human trypanosome by the movements of man in the war, for example, from the South, in Neumann's incursion, or from the Congo by the Belgians. There is no apparent reason why *T. rhodesiense*, just recorded from the Sudan, should not exist in the appropriate areas in the Congo;* (*b*) that it had been present all the time as a specific trypanosome pathogenic to man, which, in spite of the distributional evidence to the contrary obtained in the war, is widely spread in *morsitans* areas at every latitude in which temperature conditions are favourable to its development, but tends to be overlooked so long as cases are few; or (*c*) that it is simply a strain that may arise from *T. brucei* of game, temperature and other conditions being suitable, in any place in which the latter trypanosome is present and heavy and continuous concentration of tsetse is taking place in relation to man.

Whatever theory of origin is correct—and on this I express no opinion—what caused the infection to grow into an epidemic in this particular place?

Duke has suggested that direct transmission may play the all-important part—we cannot perhaps yet say the only part—in producing and maintaining a virulent strain of trypanosome in nature, as under experimental conditions, and I have shown that in this outbreak a position favourable to direct transmission, as also probably to transmission, direct and cyclical, that would be almost confined to man, existed in the fact that the human population was being specially and continuously attacked by *Glossina* as a result, undoubtedly, of a previous destruction of game, and that the greatest destruction, and therefore the greatest concentration, had in all probability coincided rather particularly with the locality (Usmao and Igombe) in which the outbreak appears first to have assumed serious epidemic form. But game destruction and special attacks on man have taken place locally in parts of the territory in which, nevertheless, so far as we know, no outbreak of human trypanosomiasis has followed.

Coincidental factors seem to complete the explanation. Thus in 1917 the bush-dwelling Bagwe (Wasukuma) were brought into contact with the heterogeneous collection of humanity that accompanied the Ikoma pursuit and were much scattered,

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* While correcting the proofs of this paper I have been shown by Dr. Newham a war-time report (I believe unpublished) by Wolff, the German investigator, in which the following passage occurs: "The large bodies of troops and porters have carried infection to districts formerly unaffected. I discovered three sleeping sickness patients in Mwanza District among a small number of Belgian askaris who were prisoners of war, and of these one reported that he was infected with his illness and had already been treated for it in the Congo territory. These people had brought their sleeping sickness with them from the Congo and come there in a condition to infect other districts. After this demonstration it must be admitted that a considerable number of the Belgian natives will have carried the disease through a large portion of German East Africa. All prevention and control have ceased since the beginning of the war."

The period of the war at which these prisoners were taken is not indicated (Neumann took Belgian prisoners), nor is anything said of the trypanosome, but the record is valuable and suggestive nevertheless. It also reinforces my argument in Sect. XX.

both as carriers and to avoid carrying, and were also probably exhausted by excessive porterage. So, possibly, were some of their fellow-porters who may have been carriers of trypanosomes. In 1918, and probably already in 1917, the Neumann operations having reduced food supplies and prevented hoeing, the people were scattered by a famine for the second time over the face of the country seeking food, and came into fuller contact than ever with surrounding peoples. Influenza also swept through the area, and smallpox through a portion of it. Additional game extermination took place in the neighbourhood of the larger populations in which the game was greatly reduced already.

It is stated by natives that cases with the sleeping sickness symptoms were first noted at the end of the famine (when, to judge from the date of Capt. Currie's observation, they were probably already numerous), and it is probable (*a*) that a trypanosome or strain of trypanosome actually or potentially pathogenic to man had been introduced from one of the various sources I have indicated above or was already present in the area ; (*b*) that first their other hardships and then the famine had weakened the people's power of destroying the injected trypanosomes (the great Busoga epidemic similarly accompanied a severe famine) ; (*c*) that out of several localities in which this trypanosome was present and might have caused trouble had it not been for the fly-diverting, virulence-controlling presence of game, it did actually first spread and establish its full virulence in one of them—eventually for relatively undebilitated man. In that locality, between Usmao and Ngasamo, game having been greatly reduced, the fly was devoting that special attention to human beings that we ourselves noted in this more gameless area, and that it always does devote to human beings when deprived of other food.

*Famine and game destruction* appear to be the most dangerous combination. They tend to occur together, for game destruction by natives takes place rather specially during famine, but the destruction in the Simiyu area was probably exceptional. Game destruction was taking place in that locality especially for years before the war ; it was doubtless accentuated by the relaxation of attempts at game preservation during the war ; it would have been reinforced by the killing indulged in by that portion of the Belgian expedition which passed through this country ; wherever I have travelled in the west of the territory, the destruction of game by the Belgian forces has been described to me by the natives as something quite exceptional; and it would have reached its climax finally, in relation to any game that remained, during the famine as the result of hunger and movement. And all this destruction, while it was not entirely confined to the area between Usmao and the Duma, was exceptionally effective there because this region bordered on the areas of heaviest population, and was with difficulty reached and replenished by the annual game movements. I have shown that the position was very nearly indeed that which would have been brought about had anyone enclosed a piece of country with a nearly game-proof fence and killed most of the game inside it, while leaving the human population exposed to the attacks of the tsetse. The game, it seems certain, had already increased between the famine and my visit, particularly on the Duma, yet, even so, it was very scarce as compared with the game about Nasa and beyond Ngasamo, and this difference was still being strongly reflected in the habits of the tsetses.

Whether *T. brucei* of the game then became converted into *T. rhodesiense* of man, or a human trypanosome that was present in the game or in some human carrier who lived in or visited the area secured vectors and an enhanced virulence, it was clear later that, once the initial catastrophe has occurred, man becomes very definitely the reservoir and the vertebrate disseminator. On the *brucei* view (as modified by Taute's results and Duke's suggestions) a human infect, carrying a parasite that is already virulent for man, must in any case be far more dangerous than a game animal, for the parasites in the blood of the latter would seem likely to require some passages through man, probably by means of direct transmission and perhaps at

first through debilitated persons, in order to attain the same specific virulence and produce the disease. Taute's evidence shows that it is vastly more likely that the Lindi-Kilwa foci were set going by infected man from the Rovuma or Lujenda than that each arose independently from local *brucei* infection. And it would seem perfectly probable, though not necessary, that the Usukuma outbreak itself arose in the same way from man-borne infection.

### Density of Fly not in itself a Cause.

A point that seems clear is that mere density of the fly, as such, has nothing to do with the incidence of human trypanosomiasis. In other places in the territory the fly (to judge from the evidence of the puparia) is just as numerous, yet in these, so far as we know, there is no sleeping sickness. The fly in the latter areas is living largely on game (as the proportions of the sexes show strongly), so that the fly that bites a man now will next bite a zebra, and though males—and many males—may temporarily follow a caravan, there is little intensive feeding ; whereas the fly on the Simiyu was quite largely living on man, obtaining feed after feed from man possibly for weeks (as the proportions of the sexes again suggest), because the game in that place had been reduced. From this, on Duke's view, would have followed a development or an elevation of specific virulence, a conquest of man's usual resistance to trypanosomiasis and, if all other circumstances favoured it, an epidemic. It is continuous density in relation to man that matters, and ready feeding, and these depend entirely on the presence or absence of game.

### Density of Population unessential.

Nor does massed population seem completely necessary for the propagation of an epidemic—I do not say of a great epidemic, for an epidemic needs fuel in order to grow great. In this instance we had small, family villages scattered through the woodland widely or closely, but not densely. All, then, that is needed apparently in this respect, is that villages, large or small, should lie so near as not to preclude ordinary social contact, and that the fly should, in considerable numbers, be devoting its special attention to man. It is true that where an adequate enforcement of the game laws is absent, great population means great game destruction and special concentration by the fly on man.

In relation to a fly that likes man as well as it likes other animals, a population of man that has locally merely outstripped that of the other food-animals in availability might, without any complete destruction of the latter, attract the fly rather specially to itself. The matter would be relative. This may be the position in relation to *G. palpalis* everywhere or in particular localities, and I am convinced that it could be the position as regards *G. swynnertoni* were it not that population in this case means clearing of bush and reduction of fly. It may, I think, be said that the extent to which a given species will attack man decides whether that species will act as a vector, and, secondly, that the length of time during which a fly that will fairly readily attack man is led by circumstances to concentrate on man will perhaps decide whether, in a given locality, the result will consist in isolated cases and small foci or (with debilitation at first present ?) an epidemic. *G. brevipalpis* and *G. austeni* will probably never, in practice, carry human trypanosomiasis. *G. pallidipes*, also, to a vastly greater extent than *morsitans*, is a wild-mammal fly and is unlikely to become of importance, though the relation, if any, of the adjoining *pallidipes* belt to the sleeping sickness outbreak associated with *G. palpalis* on the two rivers in south Kavirondo is worth investigating. *G. morsitans*, with human infection present, will probably produce occasional cases, even where extremely localised game removal, as along a road or as a result of local heavy shooting, makes it concentrate on man, and would produce an epidemic under the conditions

existing on the Simiyu ; while *G. swynnertoni*, now very much a "man" fly, and strains, at least, of *palpalis*, might, theoretically, produce the disease merely where man is so very much more available than the game that it becomes easier to prey on him.

**Corroborative Observations from other Sources.**

Taute and Huber specially state of the roadside foci of human trypanosomiasis behind Kilwa and Lindi and further south the most interesting fact that they were confined to water-holes and river-banks that were the halting-places for Yao labourers passing from the southern infected foci to the Lindi-Kilwa plantations, and that cases did not occur in the surrounding country ; and they remark that one of them, the Kilwa (Kilimila) water-hole, was not on the main road used by the local population but on a deviation particularly used by these labourers from the infected area. *G. morsitans* is stated to have been abundant at and around the water-hole, and it is likely that we have in each of these instances a case of the introduction of man-borne infection into the main human meeting-places on roads on which the fly was concentrating much on man. Taute mentions also (Minutes of Evidence taken by the Interdepartmental Committee on Sleeping Sickness, 1913–14, p. 231) that the sleeping sickness districts of German East Africa were in general ones that were not very rich in game, and (in another place) he quite correctly lays stress on the fact that *morsitans* is not merely a game fly, but a man fly also, and that it will make man its chief blood supplier after the shooting-off of all antelopes. Shircore, in one of his very excellent contributions to the subject of the tsetse problem, has referred to the concentrations of the fly that in Nyasaland collect round villages in forest and on the paths between villages, "so that the villagers are constantly fed on for the greater part of the year by these flies, both in and every time they leave or return to their villages" (Minutes of Evidence, p. 274). I understand that he refers to the sleeping sickness area.

May (*op. cit.*, p. 214) states, "The majority of cases have been found in the vicinity of main traffic routes (game is generally less abundant in the vicinity of these routes than in many other localities . . . where the disease is absent or rarely found), this lending some support to the view that it is transmitted from man to man rather than that game is the chief reservoir. This occurrence of the disease along the main traffic routes is so marked," etc. Still speaking of Northern Rhodesia, he goes on to suggest that "taking into consideration the scattered nature of the population, the disease might remain for years, if not indefinitely, endemic ; slight local exacerbations from time to time being accounted for by some such circumstances as increased opportunity of infection for the fly" [*e.g.*, by concentration due to game removal.—C. F. M. S.]. He attributes the larger number of cases in Nyasaland "to the much greater density of the native population along the shores of Lake Nyasa and consequent increased opportunity for infection and transmission." That even famine, by itself, will not necessarily lead to the development into epidemic or sporadic human trypanosomiasis of the Nyasaland type is shown by Kinghorn's statement (*op. cit.*, p. 259) as to the trying years 1911–13 in Northern Rhodesia. This might suggest that the disease was endemic in the latter country, but that Usukuma was virgin ground, or, more likely, that the famine in Rhodesia did not coincide to the same extent as on the Simiyu with a marked diminution of the game and a widespread and lasting concentration of tsetses on man. Both May and Kinghorn draw attention to the retrogression of the disease in Rhodesia "although all the conditions favourable to its spread, viz., *an abundant reservoir*" [the game—the italics are mine], "an ubiquitous and plentiful vector and lowered vitality among the natives, have been present" (Kinghorn). May in his evidence before the Committee (p. 211) gives an instance of a traction-engine road (from the Kansanshi Mine into Belgian territory) on which practically no game had been seen for two years, yet tsetses

(*morsitans*) were, day after day throughout the journey, most plentiful and most vicious. There was very extensive traffic on the road, and Dr. May believed that the fly was subsisting on man. In this case no sleeping sickness had resulted, but the elevation was 5,000 feet and over, and the result in this place of the removal of the game would appear to give us the key to all the previously quoted observations.

Passing to *T. gambiense*, we may note that more than one observer mentions the relative lack of game in the sleeping sickness areas of the Congo, and that Roubaud associates the most intense infection with the greatest lack of game and with special concentration on man by *G. palpalis* (*op. cit.*, p. 226). He also suggests the utility of enquiring whether, in those regions in which Nyasaland sleeping sickness is present, *G. morsitans* does not live in closer intimacy with man than it does in other inhabited areas. I would substitute "localities," "roads" or even "villages," for "regions" in an area like the Luangwa valley in which the disease is sporadic. Roubaud suggests the existence of local races of *Glossina* that have become specially sensitive to infection by a given virus—a point to consider in relation to our Usukuma outbreak. Bouffard mentions small endemic centres of the disease in the French Sudan in which game is definitely absent while tsetses are everywhere present, but believes that in the vast belts of the Banifing and the Black Volta some wild animal, perhaps hippopotamus, supplies the infection to man. Yet his observations as given, to the effect that the danger of infection, amounting almost to certainty, is confined to the two or three months of the year during which antelopes are precluded from coming to the river and the concentration and eagerness of the fly in relation to man become extraordinary, suggest to the reader that the infection may be brought about by intense direct transmission as between the members of the boat-crews should any one amongst them be a carrier of the trypanosome. Dalziel (*op. cit.*, p. 251) states of the Munshi tribe in Northern Nigeria that they "have not exterminated, indeed, but greatly reduced the number of wild animals. Tsetse flies abound, however, and in certain localiities sleeping sickness is endemic." In this particular case partly immune dwarf cattle are regarded as possibly forming a reservoir, but it may be that without them matters would be worse. Finally may be mentioned the records as to the scarcity of game on the shores of Lake Victoria that were devastated by the epidemic. It would be of interest to know whether as the result of the Busoga famine the natives had greatly reduced any important food-animal of the fly and so intensified its concentration on themselves. Mr. Hobley tells me that the dearth of mammals in Kavirondo was extraordinary.

These latter observations refer to a different fly and a trypanosome that is now more resistant to human serum than is *T. rhodesiense*; but the knowledge that man is the all-important reservoir in the west renders it advisable that we should apply the logician's "razor of Occam" to the case of the sister disease before we give weight to alternative hypotheses.

### Probable Utility of the Game.

The definitely mentioned failure to find sleeping sickness away from the much-used labourers' route in Taute's foci, the absence of known sleeping sickness on certain roads much crossed by game in Tanganyika Territory—not that this line of evidence can yet be regarded as secure—May's evidence, and the general facts of the Usukuma outbreak, suggest that the trypanosome does not gain and may not keep up its full infectivity for man in places in which the fly does not depend, or ceases to depend, on man for its food; further, that man, at least for all practical purposes, is the only reservoir; and that in either case an epidemic, once started, is likely to cease to spread *as an epidemic* when it comes into definite contact with a game population that is sufficient to break freely the continuity of the attendance of the fly on man, and reduce its avidity, though very local reductions of the game might

be accompanied by occasional cases* which, as the potential first cases in a possible epidemic and for the cause referred to on p. 345, would be particularly virulent individually.

The presence of game would thus be protective to man. It was impossible to resist this conclusion when, in and north of Nasa, I obtained my final information and evidence on the distribution and movements of the game and a continuance of the striking evidence that was being afforded by the fly itself. I had already seen *G. morsitans* concentrate on man during very temporary absences of game, but the Usukuma evidence suggested a next step, that, in relation to a fly closely allied to *G. morsitans*, man is capable of replacing the destroyed game as a main source of food-supply ; and further, that such a position may, in point of fact, lead to an epidemic of sleeping sickness. On propounding this conclusion (as to the utility of the game) in Entebbe, I was most interested to hear from Dr. Duke that he had arrived at the same view as a result of observations in Uganda and had published it in a number of "The Field" which I had not seen. I am glad to have been able to confirm his view, and I think it is of particular interest that the conclusion should have been reached in relation to two very different tsetse-flies, two very different game faunas, two native populations with quite different habits—one of lake fishermen, the other of people with inland pursuits—probably two different trypanosomes, and from the two different standpoints of protozoology and entomology.

## XX.—Possibilities of Spread.

Both the details of the spread of the Usukuma outbreak and those I have quoted as recorded by Taute suggest that sleeping sickness, once set going, is capable, through the agency of human beings who travel or are visited in the presence of tsetse, of spreading and reproducing itself in places and under conditions in which the fly is paying special attention to man, but in which, nevertheless, the disease had never been able to make a first start while it lacked this special infection by man. Further, the Kilwa water-hole focus, infected (it seemed certain) by the travelling Yaos, was, as Taute states, not less than 150 miles from the infection on the Rovuma and much further from what was regarded by the German workers on the Rovuma as the original source of that infection—namely, Mwembe or Kumembe, a thickly populated area of the Lujenda valley. It becomes, therefore, of the utmost importance to study the larger movements of the natives with a view to their judicious control, and to carry out a most thorough search for sleeping sickness through the west and south of the territory.

It is certain that we cannot know the position to-day as regards the distribution of infection. In view (1) of the Belgian occupation of the west of the country during and since the war, with its recorded introduction of infects and its alleged exceptional destruction of game ; (2) of the fact that traffic exists between the infected Usukuma area and Uzinza, the fly belt south of Eyasi and elsewhere ; (3) of the fact that foci of *T. gambiense* infection existed in the territory itself till fairly shortly before the war, and of *T. rhodesiense* still later ; (4) of the general movements of men in the war, and (5) of the fact that Usukuma was not the only area which suffered during the war from famine, heavy porterage and game disturbance and destruction such as might conduce to heightening of virulence in any appropriate trypanosomes present ; it will be surprising if we do not find foci of sleeping sickness of one or other kind existing to-day in the great *Brachystegia* belts, infested with tsetse, that extend

* With a trypanosome pathogenic to man already present, any bite from a fly which had shortly before bitten an infected person and picked up trypanosomes might be expected to be capable of infecting a sufficiently susceptible person ; and it is possible that such infections, and infections of a cyclical nature, often take place with game present ; but the persistent biting by many flies that results from hunger in the absence of game would render infection more likely even for the probably somewhat resistant native by greatly increasing the number of trypanosomes injected.

from west of Mwanza Gulf far south through Tabora to Lake Tanganyika, and in the south. The Usukuma instance and similar instances of undetected outbreaks under the Germans show clearly how easily such matters may be overlooked, and it is known that sleeping sickness increased during the war in the French and Belgian colonies.

Trade and game are the chief factors causing movement from and through the Usukuma infected area, though numbers of natives go also to seek work in Kenya and some to the coast. There is a regular movement to the Uzinza tsetse area to buy hoes, and the natives stay there in the tsetse-haunted bush and work to pay for their hoes. Many go to the south end of Lake Eyasi to dig salt, and they carry this and tobacco not merely to their own country but to Shirati and Ukerewe and elsewhere to sell, to Ikoma to exchange for wildebeest skins and tails, and to the Mbarangeti to exchange for fish. Thither also the Wantusu go to fish.

The hairs of the wildebeest tails are used as cores for twisted wire bracelets for their toughness and flexibility, and are so much in demand that it is said that even natives from Tabora, Chinyanga and Uzinza go to the Ikoma country to buy them from the hunting tribes there, and pass through the infected Sultanates in doing so. They also attract natives from the infected areas of the north, and a capture was recently made near Ikoma of 43 wildebeest tails in the possession of four Wakavirondo from the Kenya border, who had bought them at Ikoma and were taking them home to sell.

A movement of cattle, present or past, was spoken of from Busia in the Chinyanga district to the Masai country to exchange breeding stock for oxen, which were then taken to Tabora to be sold for slaughter. It is interesting that it should be possible to take cattle through Itilima and Ututwa (this being the route indicated) without so many becoming infected as to make the loss prohibitive.

Finally, there are the members of outside tribes who have settled amongst the Bagwe or Wasukuma, and who by their intercourse with each other and the main tribe may spread the disease. The Washashi, with their headquarters in Musoma, are to be found in some numbers throughout, having been scattered, their Sultan told me, by famine. The wild, dwarfish Wahi or Bahi, of south Meatu, are purely hunters ; they follow the game in its movements, but they are also said to visit the settlements to their north and those of Chinyanga to their west to exchange rhinoceros horns, skins, tails and honey for food, and they appear (from rather doubtful native statement) to have a branch beyond Eyasi. The Wataturu of the upper Simiyu region are said to have constant intercourse with their branch south of Lake Eyasi and to pass through the fly area near Lake Eyasi.

The movements of the game are of importance both because they are followed by the hunters, who, in this country and particularly perhaps in Musoma, appear to comprise a very large proportion of the native population, and because if the parasite is one that can retain its virulence after passage through game-animals, these may themselves become infected and instrumental in spreading the infection ; but of this there is no present indication.

Ikoma may be taken as the local centre in relation to game. A broad colony extends thence eastwards between and about the Rowana and Mbarangeti rivers, and another populates the Serengeti plain southwards. It is said that the headwaters of the two rivers just named dry up, as do the waters of the Serengeti plains, and that the Duma and Simiyu headwaters and the Ngasamo stream do not do so to the same extent. This leads to a dry-season movement of the Mbarangeti-Rowana game eastwards along the two rivers and south-eastwards (through Masanza-Mdogo and even Nasa) to the Lake, and southwards through Ututwa to the Ngasamo and Duma. At the same time a proportion of the Serengeti game comes eastwards through Kanadi to the Duma and Simiyu headwaters.

From this may be deduced the movements of the hunters also to and from the borders of the infected area and the points at which the game from divers quarters intermingles. Also the localities (abutting on population) in which the game is liable to the greatest destruction and that particular locality (inside and west of the cleared Luguru arc and extending to Usmao) in which it appears to be least capable of being replenished by the annual movement to water.

To summarise: Tsetses alone are unlikely to spread the disease far, even if it is propagated through cyclical transmission, owing to the considerable breadth of the barrier round the main Usukuma belt. Game, on present evidence, does not seem likely to spread it, and I know at present of no great movement of game between the main Usukuma belt and the tsetse belts about it. But an infected man going out, passing through or having entered for one of the many purposes I have enumerated may subsequently sit down and talk in a village or road-side halt in any tsetse belt in the territory in a locality in which man is for the time being the centre of attraction for the tsetses that he was in the Simiyu area during our visit, and start a case or two or an epidemic. It is improbable that the last will come about in any place about which game is present abundantly.

## XXI.—Immediate Local Measures.

I have not heard what were the recommendations that were finally made by the Acting Principal Medical Officer and adopted, but there can be no harm in stating that the urgent local desiderata when I left seemed to us to be these: to finish the delimitation of the outbreak and of the tsetse area; to segregate the sick in fly-free country, and, for the reasons to be stated below, to evacuate the remaining population immediately the crops should be harvested; to protect people who must still, after evacuation, pass through the woodland either to water or during essential travelling; so far as possible to prevent entry into the infected wooding for any purpose whatsoever; to prevent, for as long as might prove to be necessary, all passage of people between infected and uninfected tsetse areas in our territory or across the Kenya border; if at all feasible (cyclical transmission being presupposed and infected persons having been removed already), to hasten the decease of the tsetse already infected—pending evacuation; again, if possible, to prevent the infection of the game with the trypanosome in case the latter should be capable of maintaining its pathogenicity for man after having been transmitted to the animals.

These would be emergency measures. I was myself anxious, and we thought it distinctly useful, that the continued presence of workers and of natives in the area should be utilised for observation of the primary centres of the fly during the dry season already commencing and for such further acquirement of knowledge regarding a new and highly dangerous tsetse as would help us to initiate later an effective campaign against it such as might assist early resettlement and enable us to utilise the latter to the best effect for the final eradication of the fly. To such a campaign the evacuated, barrier-encircled Simiyu-Duma area would rather particularly lend itself.

Here I ought to say that the problem as regards native co-operation appeared to be very different from that which I believe confronted the British East African authorities when the evacuation of Kavirondo was, long ago, in question. We had conferences with the Sultans, and I was most struck with these hereditary native rulers of the district, with their information and outlook, their apparent ability and hold over their people, their ready grasp of the matter in hand and their shrewd suggestions, and their keenness to support the Government in an effective tackling of the outbreak.

The local measures that (in final consultation between them and the Senior Commissioner) were decided to be useful and, with good supervision, sufficiently practicable, and with regard to which they promised their hearty co-operation, were complete evacuation of the woodland sections of the infected sultanates; the

people evacuated and all gardens to be nowhere less than half a mile from bush ; no entering of it for any purpose except on cleared roads ; all cutting of wood, etc., to be on the edge of the bush—an approach to the fly that it was impossible to avoid in a country clear of wooding but that would result in a steady invasion of it ; the road to be cleared from Luguru to Sengerema and from Maswa to Nasa to provide for the main traffic of the country, also another road (already for the most part clear) following the Lake shore through Nasa to Mwanza ; a path to be cleared (where necessary) to water from each group of villages ; some general effort to be made to keep bush from growing up within cleared areas ; and burning of the bush areas (by then evacuated) to be postponed each year to a given date, the cattle-owning population meantime continuing its custom of protecting its grazing by burning around it an early fire-guard that should not be allowed to spread.

The necessity for some adequate control of the hoe traffic or its discontinuance, for the continuance of the salt traffic only through cleared villages and under such safeguards as might be possible, and for clearing round bush villages immediately surrounding the evacuated areas, was also recognised. Some details with regard to the measures mentioned may be of interest.

### 1. Evacuation.

With direct transmission as the only factor in the spread of human trypanosomiasis a completely successful segregation, or successful treatment alone, of all infected persons should, theoretically, suffice to clear an area rapidly of the disease, and treatment is the line on which the French are working in their colonies. But (*a*) concealment of cases may take place ; (*b*) detection of all infects cannot be expected even when there is no intentional concealment ; (*c*) the problem of evacuation was, in this case, exceptionally simple, a fraction only of the population living in the bush, cleared country being present close by in each Sultanate to move to, and the co-operation of the more responsible natives being assured ; (*d*) direct transmission as a sole factor, though attractive as a working hypothesis and just possibly true, is unproved, and should cyclical transmission play any great part and long-lasting infection of the fly and of the game be present, the area would be in the highest degree dangerous, and it was important to evacuate it at once ; (*e*) the position otherwise also was unique and possibly full of danger ; here, for the first time, was a very definite epidemic of human trypanosomiasis carried by a fly of the *morsitans* group ; it was in a territory more than half of which is infested with *morsitans* flies and which adjoins great territories similarly infested ; and it was in a fly-belt that was connected, both by the "stepping-stones" of the Chinyanga-Kahama belts and by a constant native traffic, difficult or impossible to control, with one of the most extensive and important *morsitans* belts in the territory ; and (*f*) an immediate decision was necessary, as otherwise it would be too late to hoe for crops in the new locations.

In the face of such considerations we had no hesitation in recommending evacuation. The measure is a sound one also from another point of view. Instead of dissipating their energies, scattered through the woodland in unselected spots, clearing nowhere enough to have the smallest effect on the tsetses, the people evacuated would swell the numbers of those living outside the fly area, who by the mere fact of settlement are tending to destroy the infested bush from its outskirts inwards.

It will be completely impossible to prevent these people from re-entering the bush from their new villages without the employment of much vigilance, a considerable staff and an Administrative Officer in special control, and it was recommended that these should be employed ; for even a marked check on such movements will be useful, and Uganda experience shows that in moderation they will do no harm once the main conditions for an epidemic are removed. With their villages all in clean country as the result of evacuation and the real danger—the bush village—extinct, the chances that infects will be able to spread the disease to the extent of causing a renewed epidemic will be very greatly lessened.

### 2. The Protection of People who must pass through the Bush.

Here it was a question of the minimum width of clearing. In order to safeguard the travelling population adequately, while exposing for as short a time as possible the large number of natives who would be engaged in making the clearings, it was urgent to find this out. It was particularly important in relation to a fly that had already shown itself to possess habits of movement that had been recorded hitherto for no other tsetse.

While for the reason I have stated (p. 334) I had to leave the completion of my experiment at Zagayu to Dr. Maclean and Mr. Tully, I was not prepared to recommend a clearing of less than 150 yards on each side of the road, and I think that when the grass is short more will be required for complete protection. But it will be well to push through a somewhat narrower clearing in the first place in order the more rapidly to confer some measure of protection on travellers.

Fords especially and other halting-places should be cleared, at the very least, to twice or three times this width, as it is here that natives halt long enough for belated flies to come dribbling in (p. 336) and that, with bush present, the flies leave their carriers and form dangerous concentrations. Also the natives themselves at such places move about in search of wood, and the smaller the clearing the greater the number of flies they will bring back to the shelters. The scattered bushes and trees round water-holes that have no effect on the conservation of the water should be cleared also.

Whatever clearing is made it should be thorough. All trees should be cut, and they should be cut near the ground, at once chopped up and piled on the stump. When dry (in three or four weeks in the dry season) they should be burned and the remnants repiled and burned out finally. This kills many of the stumps, and may help to some extent to prevent that dense regrowth which in two or three years becomes more acceptable to tsetse than the uncleared bush and which must at all costs be prevented.

### 3. The Prevention of the Passage of Infected Persons to uninfected Tsetse Areas.

In the German agreement with the Territory's northern neighbours it was arranged: (*a*) to take such steps as might be practicable to prevent natives of the respective territories who are suspected of being infected from crossing the border; (*b*) to detain or segregate natives coming in and found to be infected; (*c*) to prevent natives from crossing into areas declared infected; (*d*) to lose no time in notifying infected areas; (*e*) to establish segregation camps at adjacent points on either side.

This is purely an administrative and medical problem and I will not discuss it here. The dangers and difficulties have been indicated in Section XX, and, in the map, I have thought it interesting to show (over a small patch only) some of the native paths to illustrate further the difficulty of preventing natives from crossing the border or of otherwise controlling their movements.

### 4. Clearing round Villages.

The measures already enumerated, and particularly the effective segregation and treatment of the sick, constitute fairly full prophylaxis in themselves. An additional measure that seemed to us advisable—and Maclean was specially anxious for it—was the clearing of the bush round all villages and gardens in the areas surrounding the evacuated country. This would comprise the villages most likely to contain undetected infection and most likely to be visited with any frequency by infected people, and though the measure would not free the villages completely of tsetse, it would at any rate prevent the very wholesale infestation I have described and to that extent lessen the chances of infection.

It seemed that even a larger measure would be on the safe side, namely the clearing of villages throughout the tsetse-infected areas surrounding that of the outbreak, and particularly along such routes as that to the salt at Lake Eyasi, but where game is abundantly present clearing may be quite unnecessary, and one does not wish to harass unduly people whose co-operation is essential to the success of our more necessary measures. The measure I suggest on page 367 might suffice.

### 5. The Hastening of the Extermination of the Tsetses already infected.

*Destruction by fire.*—It is probable that a large number of tsetses in any case fail to survive the hard conditions of the height of the dry season, and these conditions would be intensified by thorough burning.

The question arose whether we should sacrifice the anticipated effect of a really late fire on the bush and the more exposed puparia and try to produce an early effect on the fly on the wing—which, if cyclical transmission were an active factor, might, in thousands, remain capable of infecting people or perhaps the game. The matter was really decided by the certainty (confirmed by information from the Senior Commissioner, Tabora, to the same effect) that it would be impossible this year to preserve the grass after the end of August. Evacuation was to take place in August, and it was decided that the grass should be kept unburnt, if possible, till the 31st August. I have since heard that it was not possible to do this even till August.

I have always foreseen that it will take three or four years fully to convince the natives generally that the Government is in earnest in this matter and to secure their co-operation.

*Catching the flies with nets.*—It seemed likely that with man as the special object of their continuous attention, the majority of the infected flies should at a given time be found about infected villages in the bush and on the bush paths between them. Smart local natives were engaged and, having been trained to catch flies, were returned to catch in their own localities in specified places until after the fires or up to evacuation. It was hoped that a system of rewards would ensure their carrying out the work with some thoroughness and that the large crop of infections which (on native information) appeared to take place "at hoeing time" might even be to some extent anticipated. At any rate, in view of the considerable captures made by the natives with myself at one or two such spots of flies a great many of which should have been infected if cyclical transmission was present, it seemed well worth attempting this disinfection of the village flies now that the accomplished segregation of infective persons would have removed the source from which the flies crowding in to replace those caught might have drawn fresh infection.

*The use of limed screens.*—This method was also considered, and Mr. Ralph, the Public Works foreman in Mwanza, made me an excellent revolving screen on the lines long ago suggested by Dr. Shircore (Trans. Soc. Trop. Med. & Hyg., London, ix, Jan. 1916, pp. 101–103). Life-sized silhouettes of men were painted in hartebeest blood, which dried brown, on each of the four vanes (three would have moved better) and the effect as these turned was most striking. From a short distance and partly concealed by bush it looked like an endless succession of natives turning a corner. Mr. Tully and I caught 17 tsetses off it in about 20 minutes, near Zagayu, but the impossibility of obtaining good bird-lime prevented its proper trial. That referred to took place in a spot where the flies were not at the moment abundant and, while it is possible that we with our scent assisted to attract them, they went to the screen rather than to ourselves. I tried it both with and without a loin-rag, freshly removed from a native and placed on it, but could not decide that it made a difference. The dry blood attracted house-flies in great numbers, but the tsetses settled as freely on any exposed woodwork; they avoided the white background. The screen was finally smeared with indifferent lime and set up on Mugasiro island, but, the bird-lime having dried on the way over, caught three flies only (*palpalis*). A small simple

stationary screen composed of a square of khaki stretched between two sticks at 4–6 feet from the ground caught six in the same time. The figures are too small to be a guide, but I had found earlier by watching it that flies were attracted to this stationary screen and, only because it is so much simpler and cheaper to make, this may be the best to use where many screens are required. The use of screens necessitates a thoroughly reliable native in charge, and one who is not interested in the catching of birds, to renew the lime frequently, and the latter substance has to be put on so thickly that, even were it good, it would probably be uneconomical as compared with commercial fly-gums. The use of the latter substances is indicated, and the screens may prove a useful reducer of tsetses in bush villages and (as Shircore suggested) on main paths—the two places in which continuously man-feeding tsetses would most abound.

*The probable value of propaganda* was also fully realised. With the native once well convinced of the danger of being bitten, the distribution of small nets amongst the villages might be the best remedy against the "direct transmitter."

6. **To prevent the Game generally from becoming infected with the Human Trypanosome.**

In first reporting on this investigation I was impressed by the risk that the trypanosome might retain its acquired virulence for man even after cyclical passage through the fly and transmission to the game, and by the fact that, as little game was probably infected as yet, and that mostly between the Duma and Simiyu, we might utilise the impending evacuation to place the natives in such a way as to complete by a broad strip of settlement the Maswa-Luguru arc of cleared country, round by Ngasamo and the Kilalo clearing to the Lake at Nasa or Masalu's; and, in the opposite direction, either (shorter) to the open country of Nung-hu or (longer) along the road that it was proposed to clear from Luguru to Sengerema. This would make nearly game-proof the barrier of settlement that already stands in the way of the annual southward and westward migrations and (on the hypothesis stated) prevent more game from becoming infected and from carrying the infection far and wide. I recommended that the natives should be so settled, if possible, and there can be no doubt that this will be a useful measure either to meet such a situation as I have just suggested or as a part of the policy, of which I shall shortly say more, of breaking up the fly-belt so as to allow us to attack it in detail, isolate future outbreaks, and check the movements of the fly. It could also serve as a base for invasion inwards by reinforced native settlement should that be our eventual measure, and anything approaching an absolute barrier against the game might enable interesting periodical investigations of the trypanosomes in its blood to be carried out.

If, on the other hand, the trypanosome loses its virulence for man on passing into the game, the measure would still be useful in the other connections I have mentioned. Yet, on this same view, it might be a very great pity to place any obstacles in the way of flooding the area with game.

## XXII.—A Campaign against the Fly.

The following remarks on measures refer rather to the Territory at large than to the Mwanza district only, but they are for the most part as applicable to the latter as to the former. Measures against tsetses fall into two categories—wholesale (or catastrophic) and precise. In the first I include such things as general late grass-burning, wholesale clearing of bush and game destruction. In the second, I include highly localised measures against, for example, the primary centres of the fly, these having first been carefully located.

Each of these categories is sub-divisible into (*a*) special and usually expensive measures—such as special clearing, the breeding and release of parasites (least expensive), the provision of artificial "trap" breeding-places, or game destruction

by paid men; and (*b*) incidental measures, consisting in the mere diversion into channels hostile to the tsetse of some process or agency already at work in the country and costing little or nothing to divert or to organise.

**Wholesale Measures.**

*Game Destruction.*—The destruction of game animals over any great area by men specially employed is too expensive to contemplate, and unless the area or a broad barrier round it is at once fully settled it will gradually fill with game again.

Game destruction carried out by means of arming the natives and allowing unlimited shooting might succeed in decimating the nobler game over areas of savannah forest that are nearly devoid of thicket (though probably not, for such areas are also poor in natives), but in most areas would leave the bush-pigs (which are probably quite inexterminable) and other small animals. These live in the thickets that result from the coppicing effect of the native's method of cultivation aided by his usual untimely burning of the grass, and appear to be keeping the fly fed to-day in certain areas on the coast from which the bigger game has gone; so that when the native later invades the cleaner savannah forest areas that we have, let us suppose, cleared of fly by killing the animals, his thickets, with their pigs and *their* fly, will accompany him, and we shall have gained nothing, ultimately, by killing the game. This sort of position actually exists to-day in much of the territory in which there is a fair native population. It takes a very large population of men and of cattle combined to produce, in what is normally a bush country, the temporary freedom from bush and fly that exists in parts of Tabora and Mwanza. In such a case the clearing of the bush automatically eliminates the tsetse and there is no need for further measures against the game.

Game—it is true of certain kinds in particular—would seem capable of carrying tsetses into cattle-pasture and so causing small outbreaks of nagana, but our study of the position at Mtukuza, where four herds of cattle were running in apparent and alleged safety in a limited open space closely hemmed in by tsetse in which the game from the surrounding country also congregated, was illuminating in this connection. Several head of game were shot here, but the only flies found either on them or in the mbuga generally in spite of special search were occasional individuals in the small clumps of trees. Shircore has also recorded that tsetses are not found on game shot in dambos except when near the fringe of forest harbouring the fly. This, with the observation that flies once carried well into an open space tend to dismount on reaching bushes or trees, shows that the real protection against this danger lies in most cases in the clearing of the bush in the endangered pasture. Similarly, bushes and trees standing near huts and gardens in clear country near the margins of tsetse areas should be cleared for protection against flies brought in by baboons, and the danger thus reduced to that which may still result from the few flies that will leave the baboons for the crops or the huts. Occasionally, as to-day near Namanyere, the bushes and trees are too many to be cleared, and steps have to be taken against a particular herd of the "wandering" section of our game animals.

Game destruction will not merely, in most cases, be useless for the production of such eradication of the fly as will enable cattle to be kept in what is now tsetse country, but is even highly dangerous to man. I have already said so much in evidence of this fact that I need not labour the point here. It is obviously by no means a policy to be undertaken light-heartedly.

*Bush Destruction.*—It is interesting to divide our secondary bush formations into three categories: (*a*) the relatively open savannah forest that tends to accompany an absence of human population; (*b*) the savannah forest intermixed with or replaced by thickets that accompanies the appreciable presence in the past of natives (or, in places, elephants); and (*c*) the country clear of all bush that accompanies continuous, intensive native settlement or intensive grazing by game and by cattle,

Such clear areas in the Mwanza district and the smallish open spaces that carry cattle surrounded by fly offer abundant proof that clearing of the bush effectively banishes tsetse. But wholesale clearing by means of paid labour resembles wholesale game destruction by the same means in being prohibitively expensive. Can we divert any natural agencies to this work ?

Open ground in the African bush is due (*a*) to seasonal flooding or swampiness ; (*b*) temporarily, to clearing by natives for cultivating or for firewood and building material, and (*c*) temporarily, to browsing by game and such intensive grazing by cattle as leads to browsing by the latter ; it is also (*d*) maintained, and in many places is capable of being gradually brought about, by regular late grass-burning. I will discuss these factors, though not in this order.

*Clearing by Flooding.*—This would in most cases entail engineering and expenditure, but opportunities to flood cheaply should be watched for. The dead trees standing in the overflow " lake " of Kidete on the Central Railway show what its effect would be on the existing bush, and its ultimate drying out would remove the attraction to tsetse that the damp margins of the flooded area might temporarily constitute. I am not aware at present that cheap seasonal flooding is applicable to any part of the Usukuma fly-belt.

*Gradual Clearing of Bush by the Annual Grass Fires.*—Simultaneous grass-burning on a great scale in an unevacuated sleeping sickness area, or in a famine area in which game is not present in sufficient numbers, may conceivably be dangerous. Our observations on the Simiyu showed that some species, at least, of the *morsitans* group, will concentrate and maintain themselves continuously on man when other foods fail, and special observation is now needed to show whether such fires are less or more dangerous than the ordinary early fires that (themselves expelling game) leave patches of shelter dotted everywhere in which the flies can maintain existence better than in well-burned areas and from which they concentrate on passing man. Pending the result, we might omit areas of this kind from any scheme of large simultaneous burning.

For other places with sufficient grass, late burning and (within strict limits) simultaneous burning will be especially useful, and it is particularly necessary in the evacuated Simiyu-Duma block. This lends itself well to grass fires, the growth of the grass, except in places (as near Nasa), being very fair. Also it especially demands late burning, for everywhere amongst the grass are now present numbers of young thorn trees of several species, some of which are already growing up and forming thickets admirably suited to the apparent needs of the fly, while others are still young enough for this to be prevented by late burning (*cf.* p. 323). The fly breeds greatly in the thickets, and to this extent late grass fires may gradually attack the pupae ; but where these are deposited under the rocks of the kopjes they are protected from the fires. Also it is a measure the carrying out of which does not necessitate the presence of large numbers of natives in the infected area.

The one real difficulty is the administrative one. I drew attention to this difficulty (which has been overcome in the past) in my report to the Mozambique Government in 1918 (Bull. Ent. Res., ix, pt. iv, p. 384). A method of fixing responsibility in order to control the fishers, hunters and honey-seekers who fire the grass is necessary.

*Clearing by Native Settlement.*—It will be noted that I have included in the map figures representing (as I understand) only the taxable males of each Sultanate in Usukuma, as given me by the Senior Commissioner. It will be seen that the population of this kind of the Sultanates west of Usmao and Nung-hu, inclusive, totals 341,806, in an area of about 3,115 square miles, or roughly 109·7 to the square mile, and that this country, except for a margin on the Simiyu, is practically all cleared of bush. It will be seen, further, that the population (of this kind) of the eastern Sultanates totals only 100,720 in an area of about 8,762 square miles, or 11·5 to the

square mile, and that it inhabits chiefly enclaves in a great sea of bush. I include here Sengerema, which is mostly bush, and exclude Nung-hu and Mwagala, in which Sultanates such wooding as remains is mostly much broken up by settlements. Nyamhanda, a little Sultanate (968) that is not shown in the map, is included in the clear country. A multiplication of the figures stated by three would give, I believe, an approximation to the total populations. This crowding of the population into that portion of Usukuma which lies farthest from the Masai, and the consequent existence of the great Usukuma tsetse belt, inhabited by one-tenth of the number of people to the square mile that exists in the wholly cleared area, is said by the natives to have been due very largely to the raids of the Masai, extending in the past as far as Seke.

A third point to note is that of the well-populated fly-free Sultanates some carry a much larger population to the square mile than do others—a population, that is, which, after making allowances for uninhabited mbugas, etc., would appear to be unnecessarily large for the purpose of keeping the country clear of tsetse. To make the calculation complete we should know the numbers of cattle also; but that they, too, are in some of the areas far too numerous is shown by the fact that it has been stated of the cattle-keeping Sultanates of Tabora that 10,000 cattle die there annually of poverty. Whether this figure is correct or not, a condition of overstocking must obtain in greater or less degree in the more congested Sultanates generally.

From every point of view, therefore, it will be a pity if the unnecessary surplus of population cannot, to its own great advantage, be encouraged to clear new homes for itself in the borders of the fly. As it is the aim of every chief to have many subjects, it would hardly, I take it, be politic to offer direct inducements to people to leave particular Sultanates, but the popularity of the woodland areas might be increased. I have been informed by the Sultans that popularity has much to do with the fluctuations of population that are even now taking place between the different Sultanates. When Mwanilanga was a youth the clear, cattle-keeping area at Zagayu did not yet exist. People came to it from the surrounding Sultanates. Tshasama (Sultan of Msalala Mdogo in Uzinza) has received, so his son informed me, much reinforcement and re-cleared much country that had previously in turn supported populations of tsetse, man and tsetse again, as the result of his own popularity and the unpopularity of one of his neighbours. So that it is certain that people can be induced to move, and now that the threat from the Masai has been reduced to a minimum the fly-ridden Sultanates might be further popularised by (let us say) the remission of tax for a limited number of years, or by any alternative methods that the Senior Commissioner may be able to recommend as useful and desirable in order to get the movement started. Growing pressure of cattle in their own localities will make people the readier to accept opportunities offered in new areas. Under this scheme we could prevent such things happening as are occurring to-day in Chinyanga. Here, as the Senior Commissioner of Tabora, Mr. H. C. Stiebel, informs me, Sultan Wamba ten years ago had a population of 30,000 with large herds of cattle. To-day, owing to their abandoning their country in face of the fly, he has only 5,000 people and proportionately reduced herds. Young wooding is allowed to spring up, and " the encroachment " (Stiebel writes) " is so gradual that the natives do not realise it until too late, and then the job of cutting back the bush is too big." The right measure in such a case is to reinforce, and not to abandon. The reinforcements are already waiting a mere dozen or twenty miles away, but through lack of any organisation *ad hoc* they remain unused. Mere timely reinforcement of the cattle would often suffice.

In Mwanza, as elsewhere in Tanganyika Territory, cattle are kept only in areas that are free from tsetses of the *morsitans* group,* so that the problem, so far as cattle

* An exception, south-east of Shirati, has been reported by Dr. Davey (*v.* p. 328 of this paper). It might repay investigation.

are concerned, is not the direct protection of the existing herds (except in the matter of providing fly-free cattle routes), but (1) the effective invasion of the adjoining tsetse areas *pari passu* with the increase of the cattle so as to obviate the great losses that now apparently occur through overstocking ; (2) the prevention of the invasions by bush, entailing invasion by tsetse, that take place as the result of losses anywhere or of temporary removals of cattle from the margins of clear country. The former point is of great practical importance. In the Tabora district alone, according to Stiebel, there are " 40,000 square miles of country, and of this probably only one quarter, at the outside 33 per cent., is actually free from fly, and that carries over 600,000 head of large stock in addition to small stock and a population of a quarter of a million agriculturists. It is a simple sum to calculate what the district could carry if we could eliminate fly. At any rate it should carry the best part of two million large stock." The immediate importance of this wasted grazing lies of course in the fact that, without the tsetse, it would save the great numbers of animals that are stated to die annually from overstocking.

I have referred to " 2 " already. At Masanza Mdogo, just north of Nasa, the bush is now growing up in parts of the still occupied area, the fly has come in in ones and twos, beasts are being lost, and the people discouraged, as the ultimate result of the reduction of the live-stock below its bush-controlling minimum through a Masai raid that took place before the war. In an area in Ututwa the same thing has happened as the result of partial human depopulation through another Masai raid. In Chinyanga, according to Stiebel, fly has crept into country where there is scarcely a bush more than six feet high—much as at Masanza Mdogo. Mr. E. D. Browne, the Senior Commissioner of the Arusha District, which adjoins the Usukuma area on the east, writes, in a letter dated 14th September 1921, " There is no possible doubt that tsetse-fly has spread into inhabited areas since March 1916, when I first came to Arusha. In the case of the Masai it has caused complete abandonment of certain areas, and in the case of agricultural natives an abandonment as far as they are concerned of the areas formerly used for grazing purposes ; such latter abandonment inevitably leads to the eventual complete abandonment of the areas encroached upon, because no native will willingly for protracted periods live far from his cattle, nor can he conveniently do so for family reasons." Mr. Browne refers, of course, to tribes that have been accustomed to keep cattle, and the fact, stated by him in another letter (10.ix.21), that the fly areas in his district are practically uninhabited bears out his view. To return to the Tabora District, " Twenty years ago Urambo area was open grass country carrying huge numbers of stock ; to-day it is one tsetse-infested bush."

One or two other instances like that of the fly-free bush near Musoma may still exist in the territory, but, in general, *G. morsitans* at least has filled up the areas in which it can exist, and in nearly every case of which I know the details it is an invasion not of game but of bush that spreads it farther. The position appears to be quite serious, and the remedy for this insidious invasion is not game-destruction, which will be completely without effect, but (*a*) such measures against the growth of the bush as I am recommending in this paper, and (*b*) protection of the cattle against cattle diseases generally ; for it cannot be emphasised too strongly that appreciable losses in a cattle area which anywhere adjoins fly means invasion somewhere by the fly, and that everything which fosters the cattle industry will reinforce our own invasion of fly areas, so that a strong Veterinary Department is, indirectly, an important measure against tsetse.

In the great, clear, populated areas of the Mwanza and North Tabora districts it is the cattle, very largely, that keep the country clear. Everywhere are stumps that, with less heavy stocking, grow up at once and form bush that harbours tsetse. On the other hand, cattle can do nothing against trees already grown, and gradual special clearing could easily be undertaken by the owners who abut on tsetse, or by

the communities, as some increase of their grazing that is not obtainable otherwise becomes necessary.

Goats are valuable for their browsing habits, and the keeping of them should be organised in tsetse areas in which they can survive. In parts of the territory it is the presence of great numbers of leopards that prevents their better survival. Game is most valuable in the same way as cattle and goats, and, where it remains in sufficient numbers, it is to-day producing the same discouragement of the bush and of tsetses as are cattle. The open-plains game in particular should be encouraged in this connection in order that it may assist us to preserve the open plains through the dry-season feeding-down accomplished by its countless herds. Once let the woody growth get beyond the power of game or cattle to reduce and tsetse will appear, and we shall be faced with the difficulty (of reducing established woodland) that exists already in two-thirds of the territory.

But even the game of the woodlands, powerless though it is to reduce the bush effectively without the initial assistance of clearing, is to be regarded as a potential ally. Elands, through their size and their preference for feeding on shrubs and trees, are the very best of the large game as potential bush-reducers. An attempt to capture and domesticate elands for farming and transport in fly-areas is being initiated, as this animal has many good points for the purpose, is very easily tamed, and can be captured more easily in great numbers than any of the other game animals ; and any temporary special attraction of tsetses to the neighbourhood of a village herd would very soon be reversed through the influence of the antelopes on the lower shelter of the fly, and, with close stocking, the position with regard to the ultimate destruction of the bush that I hope to attain similarly in places by means of late fires would come about with the end of the rotation period of the older growth. The situtungas are stated to have cleared whole islands in Lake Victoria of undergrowth and left the trees bare to a level height like trees in a park with cattle, and by doing this to have banished the fly (*G. palpalis*) quite largely from those places. This has been rendered possible only by the removal of the human population, but eland farming would combine with human population the activities of a first-class browsing animal. Naturally, presuming our trial of the animal to be a success, it will take a good many years before we can establish any widespread eland farming even in a single large fly-area, but this delay will itself be useful in meeting a temporary difficulty very soundly suggested to me by Mr. C. W. Hobley, namely, that it may take time for the native to admit the eland into the "gold currency" that is represented for him to-day by cattle. This is in any case not quite the position. The elands are mainly for native tribes that to-day possess no animal currency.

Meantime we shall be unable to invade the bush from within in this particular way, but by nursing the territory's stock, judiciously relieving congestion by encouraging movement to the margins of the woodland, stimulating the definite clearing of those margins in places in which we can at once place ample stock on the cleared strip, reinforcing communities that are for the moment being invaded themselves, encouraging the starting within the fly-areas of such new clearings as those from which Zagayu, Luguru and Kilalo grew, and, in general, making the margins of fly-infested areas the objects of a particular solicitude, we shall gradually drive these back, if we can also prevent the occurrence of such epidemics of cattle-disease as would lessen greatly our material of invasion. I have been interested to note that Taute also, evidently knowing the conditions well, recommends the systematic clearing of large expanses in tsetse borders in lieu of the present haphazard native methods. I have indicated the least expensive and most effective method of clearing them.

No measure is universally applicable in its entirety, and this one will be found less workable in relation to some tribes than to others, and be modified or abandoned in conformity with local conditions. My experience in Tanganyika Territory has

confirmed the conclusion at which I arrived in Portuguese East Africa—that special study and special measures or modifications of measures are needed for each separate locality.*

*Effect of Clearing on Water.*—In reply to the criticism that clearing (by whatever method) for the eradication of tsetse will dry up the natural water-supply, the facts observed in the Usukuma area may here be cited.

It was most interesting to note that in the great areas that have been completely cleared by native settlement there is nowhere insuperable difficulty over water, and people are able to live anywhere. Moreover, the poor savannah wooding that constituted the shelter of the fly appeared to have little or no influence in conserving the water. The streams both in it and in the cleared country outside of it dry into pools in August, and the only difference, as Sultan Mwanilanga said, was that in the cleared areas water was more abundant because there were more people and they dug more water-holes.

Naturally the clearing of primary forest, in districts in which this still exists, would have a very different effect.

## Precise Measures.

The measures I have described above are widely applicable measures amounting, in effect, to a general policy in relation to the tsetse of the territory. If we can make them successful—and, given the human material and the cattle, this should be merely a matter of organisation and watchfulness—they will both prevent the serious invasion of cattle areas by tsetse and enable us to take over from the fly all the ground we more urgently require for the accommodation of the increase of the cattle of the territory, as such increase takes place. Under such a policy the fact that tsetses carry trypanosomes acquired from the game will be a matter of supreme indifference to us, for we shall have all the tsetse-free land we can use, and the rest is a matter of careful herding.

But situations may still arise that will demand a rather more rapid elimination of the tsetses in a particular area than can be accomplished by means of our gradual invasion of the fly-belts. It would certainly be well if we could to-day eliminate the Chinyanga fly-belt and at least the eastern side of the Usukuma belt, and it is for a problem of this kind that what I have called "precise" measures may be useful. Such measures entail an exhaustive preliminary study of the locality. Primary centres of the fly, breeding-places, water-holes, streams and swamps must be located; areas of bush particularly affording egress from the centres to the main woodland sections served by them may usefully be searched for, as Shircore long ago suggested; lines of open mbuga that might be connected with advantage by clearing in order to split up the fly area should be noted, and other points of attack observed. Finally, on the data collected, the real campaign can be planned. The most important line of attack will again be clearing measures, but the clearing here will be discriminative —directed solely against the strongholds that enable the fly to maintain its hold on the country generally. These in some belts will be prohibitively abundant, in others fewer and more easily dealt with.

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* Mr. C. W. Hobley, C.M.G., who has had exceptional experience of native administration and was also in charge of the Nyanza Province during the great epidemic on the Lake, has very kindly read the proofs of this portion of the paper with a view to criticism. He regards the scheme as being on sound lines and suggests, for country in which the streams dry up, the inducement that would be offered by the erection of a few dams and, beside open "mbugas" in which the people would be settled first, the sinking of wells. Goats would be farmed first. Cattle would follow when it was perfectly safe for them to do so and the clearings would eventually coalesce.

This adds useful detail to the idea of "large locations" as centres from which to invade the surrounding tsetse-country, and it is possible that the settlement of little more than the mbugas alone would, as I have suggested under "Precise Measures," at once banish the tsetse.

*Clearing Measures.*—It should not be necessary to employ paid labour, and, if it were, the cost would be great. The resettlement of the evacuated Wasukuma, when they are allowed to return to their old area, will offer a good opportunity for the application to the Simiyu–Duma problem of the control of tsetse by judicious native settlement. A yet finer opportunity might be afforded should we find ourselves in a position to utilise the surplus population as I have suggested on page 360. Instead of leaving it to attack the woodland indiscriminately (as there suggested) from the margin inwards and from such clearings as those of Zagayu, Maswa and Kilalo outwards, we would offer our inducements to those who would settle in and clear the spots indicated by us. These spots would be the main "strongholds"—the primary centres—and by concentrating on them we should make the best use of our human material.

But it is essential that the scheme should be organised soundly and with care from the agricultural standpoint also. It should, if possible, be of such economic importance agriculturally to the country that it will not lack special fostering, and so profitable to the natives concerned in it that after the first brief period of special inducement their numbers will be swelled automatically. What, apart from foodstuffs, should be the crop? This, naturally, would be settled by the agricultural experts, but it is already likely that amongst the strongholds of the fly will figure the borders of many of the small open mbugas that are scattered so freely through the woodland, and that the soil at these places, as well as in some of the thicket areas, is suited to cotton. Native settlements here for the large-scale planting of cotton might thus at once go far to control the tsetse, and cotton is the crop the cultivation of which it is most wished at this time to promote amongst the natives of the territory. Organisation of transport, a guaranteed price for the cotton, good entomological control of its pests by a man stationed on the spot, and, for produce generally, access without prohibitive duties to the Kenya market, would encourage the cultivation of the area, which, with its water transport to the railhead at Kisumu, is a peculiarly suitable one for treatment in this way.

We should still discourage the one-family bush village. Enough people would be stationed at each centre to ensure its proper clearing and to make it capable of carrying cattle at an early date, and these cattle in their turn would assist in the consolidation of each focus as it grew. Again, the reopening and extension of the gold-mining industry of the district, if that should happen, would lead to more clearing for timber round the mines themselves and, by creating a local market for agricultural produce, lead indirectly to much other clearing.

*Cleared Barriers.*—The effect of breaking up the belt in the way referred to on page 363 is worth investigating in practice. Thus, a tongue of bush extends into the more open Nung-hu country, and it is stated that in it the tsetses are few. By broadly cutting through the comparatively narrow neck that is stated to connect it with the more heavily infested bush nearer the Simiyu, it is possible that it will be completely cleared of flies, and the possibility of doing this elsewhere also should be borne in mind. Where much-frequented paths cut across a barrier, the latter may be less effective; for though many or most flies leave a person who enters cleared ground, others follow right across it, just as flies will accompany a canoe till it lands. Where it is a case of a barrier to check the advance of a fly-belt (and here I speak of general principles rather than of the Mwanza-Tabora problems) advantage might be taken on any much-travelled path that crosses it of the flies' tendency to dismount at the first piece of shade after traversing much open ground. A few bushes or huts only (p. 334) could be left at some point on the path, together with two or three resident natives whose business it would be to clear passers-by of flies. In such a place as this a few limed screens might find their best use.

*Other Measures.*—Certain other control measures that have been proposed are very well worth investigation, such as the breeding and releasing of the fly's enemies

and the interchange of parasites in different parts of Africa. I understand that Dr. W. A. Lamborn is working on this in Nyasaland, with considerable prospects of success, and that he will shortly be in a position to supply large quantities of the parasites of the pupae. The release of the parasites would take place in the chief breeding centres of the tsetses, and it would be well, when it became practicable to do so, to carry out a trial in a selected portion of the Simiyu or Chinyanga areas.

Asilid flies of one or more species were called by the Wasukuma the "Lion of the Tsetse," and a Sultan in the Tabora district is said to have reported that a whole area had been cleared of tsetse by these flies. Unfortunately their breeding, even if they should specialise in tsetses to the extent reported, is likely to offer insuperable difficulties.

I saw relatively few drongos and fly-catchers in the fly area, and the local natives are great bird-catchers and eaters of nestlings. Possibly, as Mr. Turnbull suggested, the evacuation of the infected area may help the birds a little. Guinea-fowls, of which also I saw but few, might be particularly useful in relation to a fly that is so partial to breeding in thickets, and seeing that birds hand on their traditions to their young, the release of guinea-fowls that had been accustomed in captivity to scratch up the pupae of Muscid flies under logs and in other typical breeding-places might possibly be of use. Unfortunately any bird that had been domesticated would be at a disadvantage in relation to carnivora and man.

## XXIII.—General Prophylactic Measures.

*The Perpetuation of Areas once Fly-free.*—One of the most striking things about the cleared, populated areas is the number of small thorn trees kept right down by the cattle and goats or cut for firewood if they should grow beyond them, that stud the ground, lying in wait to renew the forest and reintroduce the tsetse as soon as any of the land is abandoned. Abandoned settlements growing up first into scrub, then into bush, and already harbouring tsetse in some numbers are to be seen on the borders of the fly, or (as at Ndagalo) in the wooding, and I have given on page 361 instances from three districts which show how serious and pressing a matter this is in relation to our cattle areas. But it is not only in the cattle areas that it is important to prevent this regrowth. The extent of country that is covered in Tanganyika Territory by old cleared ground and gardens, native and European, that have gone back or are going back to bush is enormous, and I was specially impressed in the Namanyere sub-district by the indications of extensive former occupation in country that is now entirely given up to fly. Had it been the custom of the native and the European thoroughly to stump all shambas, a large amount of fly-infested land would now either be free or require but little additional work to make it free. I, myself, by merely stumping for ploughing, cleared many acres of ground in Rhodesia from a pestiferous woody *Parinarium* that always springs again in native fields and forms thickets after their abandonment.

In the clear areas in the Mwanza district the stumps are neither over-large nor too densely growing, and it would be a matter of very small trouble in these thickly-settled parts, while they still remain thickly settled, for the natives to remove the stumps and so make their tsetse-free areas more permanently tsetse-free. They have doubtless much work to do this year in connection with their road clearings and the moving of their villages, but it has already become very necessary, as a sleeping sickness measure, that they should keep the scrub about their villages from growing up, and it is to be recommended strongly that from next year on they should be encouraged to do this not by the work of cutting back, which has to be repeated laboriously year after year, but once and for all by stumping.

It should also be a rule that any native living in a tsetse area *anywhere* shall stump his garden, and, when the moment is opportune, legislation might enact the same contribution to our campaign from the European owner of shambas. But it may be

admitted that the supervision of a general measure might be difficult, as it is not easy to see at a glance if the smaller stumps and roots have been eradicated in cultivated land under crops or weeds or lately hoed. It is easier in the case of well-stocked grazing country, as at Mwanza, for the sprouts from the stumps show up well, and at least in these circumstances (where, also, it is more immediately needed) consideration should be given to the possibility of enforcing or encouraging what will prove an invaluable measure. When we cease to give back to the fly what we have gained from it, our final conquest of it will at last have begun—through this systematic consolidation of all ground won.

**The Prevention of Human Trypanosomiasis.**

It is probable that the cost of fighting successive outbreaks like that on the Simiyu will greatly exceed the cost of detailing three or four officers for a time to sleeping sickness survey and of the small preventive measures that the survey may in various localities show to be necessary; and more than possible that in further outbreaks we shall not find evacuation the easy matter it was on the Simiyu. On the other hand, success in the trial of new drugs that is now proceeding will render evacuation unnecessary in the future. In case it should be agreed that an investigation is necessary it is interesting to note that the lesson of the Usukuma outbreak seems to be that such a survey should consist :—

(1) In the usual search for infection. Even if it should reveal no real outbreaks this will help to show us the distribution of one of the three factors, all three of them important, that seem likely to contribute to the creation of a danger-focus.

(2) In a close survey of the tsetse and of the game. The latter would include a study of the seasonal movements of the game, the reasons for them, and the length of absence of game from particular places ; an enquiry as to the extent to which game is being reduced by the natives in the neighbourhood of population living in woodland ; a record of the roads from which it has been driven away to such an extent as to cause unduly prolonged concentration of the fly on man ; and (in the tsetse survey) any other factors that might locally cause such long-lasting concentration.

(3) In a study of the meteorological and agricultural history and conditions of each area with a view to determining the liability to failure of crops from natural causes.

The combination, in an area containing many tsetse, of game reduction with a liability to famine and the presence, in or near it, of infection (or, for that matter, if *brucei* be convertible into *rhodesiense*, the first two factors alone) would constitute the area a danger-focus. In such a danger-focus game protection should be well enforced (though without prejudice to the protection of the crops), a vigilant eye kept on the welfare of the crops generally, and distress caused by their failure anywhere relieved promptly ; but it should be relieved by other means than throwing the game open to unrestricted killing. It would appear from this that the expert Departments, both in a properly organised sleeping sickness survey and in the scientific prevention of sleeping sickness, would be the Medical, Game and Agricultural. The location of scattered infects in a vast bush country would be assisted by a knowledge of the distribution of the conditions under which infection is likely to be present, and such a survey would indicate also the localities which must be carefully watched in the future.

The presence of a herd of domesticated elands at a village would probably be the greatest safeguard against sleeping sickness. If any success attends the experiment that the Game Department is now trying to initiate in this direction, that condition may some day come about. As regards the more general question of game protection, it may be said that the present Game Ordinance of Tanganyika Territory provides

for the control of dangerous game generally and for the protection of native gardens in particular, and that this last, in practice, covers the killing by natives of a moderate supply of meat. The Ordinance also gives resident and visiting sportsmen a generous schedule. Otherwise than in these respects, it protects the game. It would seem likely now that this reasonable degree of protection is not only in the interests of the game, of science, of sport and of posterity, but that it represents a policy that must be continued for the safety of the human inhabitants of fly areas. The mild killing that is already permitted may, in general, be useful in preventing so large an increase of the game near man as to leave a particularly large population of fly stranded if anything unforeseen should happen to the game, but even this danger would be robbed of much of its sting by the adoption of the simple measure I shall suggest next.

For the purposes of this paper I have practically taken the view that *T. rhodesiense* and *T. brucei* are convertible, the one into the other ; for if man's resistance requires to be overcome by transmission through man, I do not think that even the last of Taute's daring experiments has disproved this alternative. On the other hand, neither has Taute's view been disproved, and a single infective person may easily have started the Usukuma outbreak. Natives have travelled in the war nearly from one end of tropical Africa to the other and, from the most widely-separated parts of it, have visited the infected region of Portuguese Nyasaland, so that *T. rhodesiense* infection as such may have been carried almost anywhere. Even on this view, the action of the game in preventing such concentration of the fly on man as will facilitate transmission and enhance virulence must be most valuable, and its adequate preservation is still the best prophylaxis against sleeping sickness.

### The Utilisation of Cultivation.

The following suggestion of a measure that would be simplicity itself and yet of great use seems worth emphasising. Native villages may be divided into three categories : (*a*) villages surrounded by cultivation ; (*b*) villages standing beside their cultivated fields or (*c*) completely separated from them. Except perhaps, where trees and shrubs are present in a village of the first category, it is only in villages of the second kind that large concentrations of tsetse will tend to take place, and, as I have seen myself, in investigating demands for the destruction of game, it is especially the third type of village that is liable to suffer from a large destruction of crops by wild animals. These people, with their gardens and even some of their corn-bins some hundreds of yards from protection, are wantonly exposing them to attack by the game and themselves to attack by the tsetse, and it should be a sanitary rule, to be enforced as strongly as such rules are enforced in the townships, that every village in tsetse-infested wooding anywhere should stand in the middle of its cultivation and be free from bush. This means of utilising for partial protection clearing that already exists is very simple, and it will be the cause of no discontent amongst natives, who often do surround themselves with their cultivation. Villages the main crop of which is rice are likely to be the only necessary exception.

But this is only a first step. The policy in tsetse-areas should (in my opinion) be directed to the gradual elimination of the small " family " bush village and the encouragement of the " large location." The large village, or the fairly compact group of villages, will protect itself from at least epidemic trypanosomiasis by surrounding itself with really extensive cultivation ; it will be able, when the clear space is large enough, to keep cattle, first one small common herd, then, as operations extend, several herds ; it will be able to use its numbers for a better protection of its crops and even (against animals other than simians), co-operate in such special measures as the trench that the closely-settled Watshaga of Kilimanjaro have interposed between their cultivation and the elephants and pigs of the game reserve ; and it will also render the general task of administering the natives incomparably easier.

**School Propaganda.**

Propaganda on these subjects is, relatively speaking, useless in respect of the adult native, except in connection with a danger that has been brought home to him, as sleeping sickness has in relation to some of the Wasukuma; yet even here propaganda should not be neglected. But school children are far more receptive, and opportunity will doubtless be taken of the fact that schools have been opened or are being opened all over the territory to teach the children, amongst other matters of hygiene, the danger of the tsetse-fly, the advantages of cattle-keeping, the circumstances under which sleeping sickness may arise, the methods of preventing it, and the ways in which the natives can contribute to such prevention and to the conquest of the fly. A brief circular of my own on the subject of tsetses has been translated by the Director of Education (who is keenly interested), and will, I understand, be distributed, and oral teaching will be still more useful. Such teaching will help us greatly to obtain the intelligent co-operation of the native in this furtherance of his own interests as years go on.

## XXIV.—Conclusion.

**Apparent Lessons of the Outbreak.**

1. The area covered by the epidemic coincided with remarkable closeness with a section of the fly-belt in which game was markedly scarcer than elsewhere, and in which, as the evidence shows, it had been scarcer still earlier in the outbreak. More factors than contact with the game helped to confine the outbreak, but all observation indicated that the fly was here concentrating greatly on man, and that in the game area it was not; and it was difficult to doubt that this concentration, the result of game destruction, had constituted a main factor in the production of the epidemic, the other being famine. Further, on page 349 I have quoted evidence from other parts of Africa to show that (apart from sporadic cases) it is quite usual for sleeping sickness to be associated with a local lack of game and a consequent concentration of tsetses on man, and that in Rhodesia famine alone did not suffice to turn sporadic cases into an epidemic.

2. It is for protozoologists to demonstrate the rôles and relative importance of cyclical and direct transmission in human trypanosomiasis, sporadic and epidemic, but my observations demonstrated that conditions strongly favouring direct transmission are present in the normal relations of man to flies of the *morsitans* group that have been led to concentrate on him.

3. It was clear from the evidence that the infection in Usukuma, once set going, was with much regularity carried from man to man, and, while it may yet be clearly shown that *Trypanosoma rhodesiense* of man is capable of arising from *T. brucei* of the game in places in which the fly has been forced to concentrate on man through the destruction of the game, Wolff's record of the capture in this very district, by the Germans, of three Belgian native soldiers suffering from trypanosomiasis, one at least of whom was alleged to have been treated for it already in his own country, shows that there is at any rate no final necessity to resort to another explanation than the presence of an infective person for the first origin of the Usukuma epidemic.

**Local Measures against Tsetse-flies.**

In my Mozambique report (*op. cit.* pp. 382–385) I made late grass-burning my main recommendation, while I also laid stress on the advantages of judicious native settlement—settlement, that is to say, that would be confined to the points that are essential to the continued occupation of the area by the fly (p. 381). For the Usukuma–Chinyanga area, while I still insist on burning, I make judicious native settlement, reinforced locally by release of parasites or any other sufficiently cheap measure that may commend itself, my main recommendation. I do so because it appears

likely to be unusually feasible in this area (1) through the fact that we shall in three or four years have a native population that will be anxious for resettlement, and (2) because beside the fly-belt lies a densely populated area from which it should prove possible to attract recruits. We could gain experience and begin to remove the dangerous link between the greater belts by attacking first the small belt of Chinyanga, and then lay our detailed plans for the area between Usmao and the Duma in time for the return of its population. This last is a golden opportunity for such an experiment and should not be neglected. My immediate recommendation, if the Senior Commissioner of Tabora should regard the scheme as locally applicable and if Dr. Duke's findings are such as to render it inadvisable to re-people the Simiyu for some time, would be that officers of the Medical, Veterinary, Game and Agricultural Departments should, with the Senior Commissioner, study the Chinyanga belt and the resources that could be diverted to it, and draw up a plan which would then be put into effect.

I will here reiterate my conviction that the time has arrived when we can learn most about the control of tsetse in relation to man and cattle by definitely taking in hand particular problems—whether fly-areas or infested roads. I would expect much from either of the two experiments I have suggested.

### General Policy.

Development, not retreat, is the right general policy with regard to fly-areas. Where through lack of urgency or for other reasons we do not, or cannot, put into effect what I have termed "judicious" settlement, the development should take place mainly as an invasion from the borders of the cattle areas, beginning in the localities in which the cattle pressure is greatest and the human material therefore most needing assistance, and also most likely to be anxious itself to assist. Our ability at once to stock fully the country reclaimed will then keep pace with the work; the latter will concern at any time chiefly natives who already know fully the advantages of cattle-keeping, and of whose keen co-operation we shall therefore be assured, even should it sometimes come to localised measures of hand-clearing; and it will least dissipate the energies of our keen but small Veterinary Department, whose ability to take its full share in the carrying out of the measure is most essential to the success of the scheme. Government encouragement to agriculture, *e.g.*, to cotton growing, should be concentrated whenever possible in places on the margins of fly-areas or along roads that it is wished to make safe for cattle, and settlement generally should be attracted to these places by any suitable means.

The general feasibility of directing any surplus, present or future, of men and of cattle to the organised invasion of tsetse belts should be carefully examined in each cattle-keeping district, for the ultimate alternative is inevitably heavy overstocking and loss and, in places, retreat; and even the fact that we have not an adequate market for the territory's cattle need not be regretted if we can utilise the animals thus saved to us for the conquest of the tsetse.

At the same time, by overcoming the difficulties in the way of late grass-burning, by the release of parasites, by the formation of large locations instead of the family village and by starting eland farming, we should organise an invasion of the fly-belts from within. The result of a successful application of the principle of late grass-burning would consist in an ultimate opening to cattle farming of great blocks together that it might be impossible to stock heavily at once, but in which cattle would run safely in scattered herds with unstinted grazing and under the best conditions for rapid increase—in contradistinction to the other type of invasion which would have to be maintained by continuous heavy stocking accompanied by some liability to loss through insufficient pasture in the dry season. We may also find it possible, in places in which the primary centres of the fly are somewhat scattered, to reduce large blocks at a time by such measures as I have referred to under "Local Measures against Tsetse-flies."

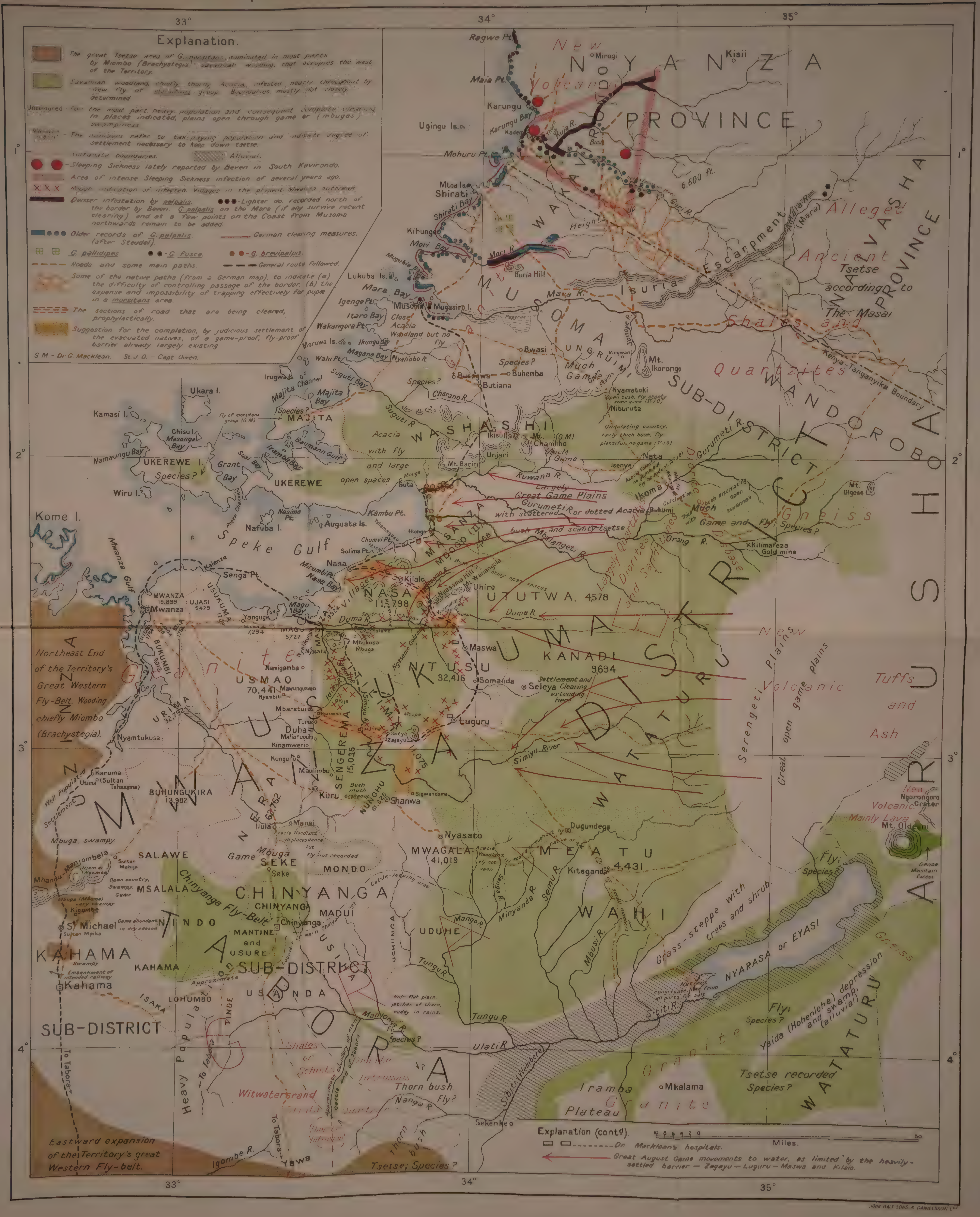
I have here summarised the policy and some of the measures by which the fly-areas of Mwanza, of the territory generally, and possibly the *morsitans* areas of any other territory, may gradually be eliminated. A continent-wide problem must be met, not by scattered measures, but by a broad, firm and persistent policy, refusing the aid of no measure which locally or generally may accelerate the attainment of its purpose. The process will be slow, but it will also be sure. It is probable that there is no other way and that an administration that is not in a position to put this policy in motion will not get rid of its tsetses. I believe that we are now in a position to make a start. The first step will be to examine in every district the position in regard to the present feasibility of the policy. The second step will be to put it into operation where it is already feasible, with such modifications of detail as the local conditions may demand, and to prepare the ground for it where it is not, by means of propaganda, the special fostering of the cattle industry, the encouragement in fly country of large locations and the organisation of their expansion, or any other measure that is locally indicated.

**Human Trypanosomiasis.**

The occurrence of human trypanosomiasis in severe epidemic form in association with a *morsitans* fly, together with the considerations I have stated in Section XX, suggests the utility of a survey of the west and south on the lines suggested on page 366.

As regards measures, atoxylisation of infects and "screens" of immune pigs appear to be the simple but comprehensive combination favoured by the French. On the prospects of a measure equivalent to the first I am not competent to express an opinion, but the wild game animals, with eland farming in fly country ultimately superadded, would with us play the part of the French animal screens. We appear to be arriving at the same conclusions on both sides of the continent. I would add the utility of making the native live on a clean site in the middle of his cultivation and not in the fly-infested bush beside it or away from it. The disappearance in this way of the thoroughly dangerous and obnoxious bush village, described on page 338, and responsible, as I consider, for the major portion of the Usukuma epidemic, will safeguard the natives very largely from any untoward result that might arise from local reductions of the game through epidemics, unlawful killing or failure of pasture. The game must be reasonably but adequately protected. There can be little doubt but that such special concentration of fly on man as does very definitely and strikingly result from the driving of the game from the neighbourhood of real bush villages and much frequented bush roads is very likely to lead to cases of human trypanosomiasis if infects carrying the pathogenic strain of trypanosome should be present. Whether such pathogenicity for man of the game trypanosome can arise in the first instance from game destruction only, without the aid of a human infect and of famine or hardship to enable the earlier trypanosomes to survive in the blood of successive persons long enough to secure retransmission might be shown by such an experiment in game destruction as has been much advocated. But to exclude these two factors is difficult, and to carry out the experiment in the face of an adaptable fly and trypanosome and of the possibility of a failure of crops before it is concluded —for man must be present, preferably in numbers, for the experiment to be of use— is to court disaster, and to risk, further, the filling of all the surrounding country with a more highly combustible material than it now contains. For it would seem at least possible that the scattered, sporadic infection of the south is merely the still radiating remnant of what was once an overlooked conflagration like that of the Simiyu, but is now, like a grass fire that has arrived amongst leaves, smouldering and flickering and working its way tortuously with the movements of persons, but virulent still and ready to blaze again should it anywhere find the dry grass of a prolonged and extensive local reduction of the game. The events in Usukuma have shown us what is liable to happen when game destruction takes place under natural conditions, and suggest why sleeping sickness bulks largest in those areas of Tropical Africa in which game is relatively scarce.

Map to illustrate an Account of the Sleeping Sickness Outbreak near Mwanza, particularly the relation of the area concerned to surrounding Tsetse Areas.

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# FIRST REPORT OF THE TSETSE-FLY INVESTIGATION IN THE NORTHERN PROVINCES OF NIGERIA.

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(Plates XVIII–XXII and Map.)

Table of Contents.



## I.—Introduction.

The tsetse-fly investigation now in progress in the Northern Provinces of Nigeria is an outcome of the proposal of the Imperial Bureau of Entomology that tsetse-fly research in Africa should be put on a more organised basis. For various reasons it is not yet practicable to inaugurate this work with funds contributed by the various Colonies interested in the problem, but the suggestion so met with the whole-hearted approval of His Excellency Sir Hugh Clifford, G.C.M.G., Governor of Nigeria, and of Dr. T. E. Rice, Director of Medical Services, that it was decided to commence such an investigation at once. The helpful interest of these gentlemen has greatly aided the commencement of the work. At present the only investigators engaged are the authors of this report, the first of whom began work in July 1921 and was joined by the other in September of that year.

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It was decided to make a rapid tsetse survey of those parts of the country in which the distribution of tsetse was least known, previous surveys from this point of view having been carried out by Macfie (1) in Ilorin Province, and by Simpson (2), whose route is shown in the accompanying map. During these journeys a site was to be selected for future experimental work, and an attempt was to be made to estimate the relative importance of the three prevalent species of tsetse—*G. palpalis*, *G. tachinoides* and *G. morsitans*. This was done by studying the distribution of these species in relation to population, sleeping sickness, and prevalence of domestic stock, especially cattle. Further, a considerable number of each species of fly was dissected fully, particularly where it was possible to contrast the different flies in the same area. In this way some information as regards their food and breeding seasons was obtained, while data relating to their disease-carrying capacities were also collected.

The ten months from July to April were spent on the survey, and in May a temporary camp was established at Mashiwashi, in the south-east of Sokoto Province, and on the northern edge of the western portion of the Kwiambana Forest Reserve, a thinly populated district where all three species of fly may be obtained. This report covers the survey and first two months' work at Mashiwashi.

It is not proposed to detail the itinerary, the course of which may be seen in the accompanying map. Briefly, the survey included the course of the Niger River from Baro to Lokoja, the Benue River from Benue Bridge (Munshi Province) to Numan (Yola Province), the proposed course of the new Eastern Railway from Kaduna to Benue Bridge through Nassarawa Province, and parts of the following provinces :—Sokoto, Kano, Bauchi, Zaria and Nupe. The survey was assisted by a number of medical and political officers, who kindly forwarded specimens of tsetse-flies with details of localities. These records are all included in the map.

We wish to express our thanks to these and to the officials who otherwise assisted us while in their districts, also to Dr. G. A. K. Marshall, C.M.G., Director of the Imperial Bureau of Entomology, for his courteous aid on many occasions. The officers of the Veterinary and Forestry Departments of the Northern Provinces have also kindly aided us by supplying information, and in other ways.

## II.—Distribution of Tsetse-flies.

### 1. Types of Forest required by the various Species.

Four species of *Glossina* were encountered, *palpalis*, *tachinoides*, *morsitans*, and *longipalpis*, and a few specimens of *fusca* were received from near Kabba. The four were never taken in the same collection, though on Baro and Lokoja Hills they occurred in close proximity. *G. longipalpis* was never found alone, being always in combination with one or two of the other three species. These last were all found together in two localities only, viz., in the heavy open forest near the headwaters of the Gaji River (Bauchi Province) and in the denser riverside forest at Mashiwashi. *G. tachinoides* and *palpalis* were frequently found together, as also were *tachinoides* and *morsitans*.

*G. palpalis* was met with alone in the dry season only on torrent streams which contain permanent, or almost permanent, running water, and where the shade trees consist of dark-leaved evergreens on steep and generally rocky banks ; the bordering shade being thus narrow ends suddenly in long-grassed land with scanty deciduous forest. The general character of such country is shown in Plate xviii, fig. 1. It is the only species which finds all its requirements in the shaded river-beds, and the wider the stream the more numerous the fly, provided that the shaded character is retained. The illustration of the Bekin River, Nassarawa, at the important ford on the Jemaa-Naraguta road (Plate xviii, fig. 2) shows such a stream heavily infested with *palpalis*, and should be compared with Plate xxi, fig. 1, which shows a *palpalis*-free river.

Torrents such as those described are common in the hilly country from Kaduna to Benue Bridge, and *palpalis* was found upon all these. Similar torrents, *palpalis*-infested, were met with around the north base of the Bauchi Plateau, on tributaries of the Bunga River, which is a feeder of Lake Chad, in seven instances alone and in one, where the river-bed was less ravine-like, in company with *tachinoides*. This species is similarly found without *tachinoides* on the torrents around Zungeru and from this place up to Gwari. East of this point the country flattens out, the streams are no longer torrents in ravines, *palpalis* becomes rare, and *tachinoides* is the common riverside tsetse. *G. palpalis* is also met with alone in the rainy season in the inundated forests around the Niger, while the other species keep on, or close to, well drained ground.

It is of great importance that *palpalis* is very scarce in excessively dense rain forest, since this allows no space for flight (*cf*. Fiske (3) ) and is also perhaps rather devoid of food. A broad road cut through such a forest does not satisfy these requirements, and, so far as we have seen, village clearings in the heart of them are uninfested by the fly except for rare stragglers.

The change in the character of the country from that which is suitable to *palpalis* to that which is suitable to *tachinoides* is well seen on the Benue River in a journey from Benue Bridge to Numan in the dry season. From Benue Bridge to the mouth of the Katsina River there is almost continuous heavy forest of dark evergreens with the larger climbing plants, such as lianas and wine palms (*Raphia vinifera*). *G. palpalis* is the dominant tsetse in these, but *tachinoides* also occurs. From Benue Bridge to Abinsi indiscriminate catches of tsetse contained 89 per cent. *palpalis* to 11 per cent. *tachinoides* ; from the latter place to a point just past the mouth of the Katsina River similar catches contained 22 per cent. *palpalis* and 78 per cent. *tachinoides* ; from there onwards no more *palpalis* were seen, though individuals have occasionally been taken here and there since the tributaries of the Benue are *palpalis*-haunted away from the main river and a few of the flies straggle down to the Benue. East of the last point mentioned the banks become drier and the evergreen forest is more patchy, with intervening savannah plains. The large forest trees are still plentiful, but lianas are being replaced by trailing plants (bramble type), such as *Dichrostachys platycarpa* (sarkakiya) and herbaceous climbers, such as the "wild yam" (*Vitis pallida*). Most of these die back in the dry season, and the patches of forest contain an increasing proportion of deciduous trees. Fierce bush fires occasionally pass through these bits of forest, consuming the dry undergrowth. Such a forest is shown in Plate xix, fig. 1, a spot near Ibi. The next marked change in the flora is the appearance of forests of fan palms (*Borassus flabellifera*) and these are tsetse-free in the dry season. Mimosa occurs all the way up the river, but near Mutum Biu it begins to predominate, and some 20 miles below Lau dense mimosa shrubberies replace the forest and tsetse-flies are no longer found. Shade trees are scanty and isolated,* and this condition obtains up to Numan, the river flowing through long-grassed plains cut up by mimosa-filled creeks. Plate xix, fig. 2, shows a mimosa creek with scanty shade trees some 20 miles below Lau, the last spot on the river where we found *tachinoides*. Above Yola, however, the vegetation again changes to forest and tsetse-flies occur.

Throughout the northern and eastern parts of the Northern Provinces are many places where *tachinoides* is found in the absence of *palpalis*. These are always areas of primary forest, often of very small extent, with shade sufficiently dense to prohibit the growth of grass or a continuous undergrowth of dense shrubs, and with water on or very near the surface. The fly seems to require open spaces apart from the bed of the stream itself and this is probably the reason why it is absent from the

* Isolated trees do not inhibit the growth of long grass—a condition which appears to be unsuitable for the fly.

narrowly shaded torrent streams. Like *palpalis*, *tachinoides* is absent or very scarce in forests so dense and tangled as to be almost impenetrable.

The type of forest is certainly the main controlling factor in the distribution of the two species discussed, but this is not the case with *morsitans*. In the height of the dry season, when the grass is burnt, this species seems to require areas of good shade in which it may shelter and from which it spreads out when the rains begin. Any of the *tachinoides* haunts would suit it in this respect, but in the Northern Provinces it is quite localised, and, as will be shown later, the localisation is probably connected mainly with its food supply.

As Simpson (2) pointed out, *longipalpis* is the homologue of *morsitans* in the wetter parts of Nigeria and consequently is much confined to the southern and western parts of the Northern Provinces. On the Niger from Baro to Lokoja, for instance, it replaces *morsitans* in much the same way that *palpalis* replaces *tachinoides* on the Benue. At Baro in October *morsitans* was caught in excess of *longipalpis* as 8 : 1, while at Lokoja these proportions were reversed. We have had little opportunity of observing this fly, the only other point where it was taken being between Lafia Beriberi and Benue Bridge in Nassarawa.

## 2. Classification of Forests in Relation to Tsetse-flies.

The types of forest given below grade into one another and the classification is a crude one, but it will indicate sufficiently to medical officers and others the species of tsetse they may expect to find in various places. The usual Hausa names of the trees, taken from Dr. Dalziel's very useful book, " A Hausa Botanical Vocabulary," are given in parenthesis.

(*a*) Heavy evergreen shade forest with such trees as *Eugenia owariensis* (malmo), *Diospyros mespiliformis* (kanya), *Vitex cienkowskii* (dinya), *Adina microcephala* (kadanyar kurumi), *Ficus platyphylla* (gamji), *Raphia vinifera* (tukuruwa), and *Phoenix reclinata* (kajinjiri). Example in Plate xx, fig. 1.

(1) So dense as to be almost impenetrable and traversed by small sluggish streams :—no tsetse or very scanty *palpalis*.

(2) Forming a narrow border to a torrent stream :—*palpalis*, and, very rarely, *tachinoides*.

(*b*) Heavy more open forest, generally filling shallow valleys containing permanent water in the north and east, but also on hillsides in the south and west ; with such evergreen trees as *Chlorophora excelsa* (loko), *Khaya senegalensis* (madachi), *Eriodendron orientale* (rimi), *Elaeis guineensis* (kwakwa), *Borassus flabellifera* (giginya), and *Raphia vinifera* ; together with a varying admixture of the following deciduous trees, especially on the outskirts :—*Isoberlinia doka* (doka), *Pterocarpus erinaceus* (madobia), *Pardaniellia oliveri* (maje), *Parkia filicoidea* (dorowa), *Prosopis oblonga* (kiriya), *Butyrospermum parkii* (kadanya), *Uapaca guineensis* (ka fafogo), *Odina barteri* (faru).

Such a forest on Pati Hill, Lokoja, is shown in Plate xx, fig. 2.

(1) Filling shallow valleys containing permanent water in the north and east :—*tachinoides*, *morsitans*, and, sporadically, *palpalis*.

(2) On flat ground or hillsides in the south and west :—*palpalis*, *tachinoides*, *longipalpis*, and, sometimes, *morsitans*.

(*c*) Less evergreen type of dense forest with permanent or almost permanent water, often reduced by farming to half a dozen trees with their accompanying undergrowth, especially common in the north and east ; contains such trees as :—*Khaya senegalensis*, *Ficus gnaphalocarpa* (baure), *V. cienkowskii*, *Adina microcephala*, *Acacia sieberiana* (farin kaya) and other acacias, *Anogeissus leiocarpus* (marike), *Erythrina senegalensis* (minjiriya), *Mimosa asperata* (kaidaji), with thickets of the trailing thorny leguminous *Dichrostachys platycarpa* (sarkakiya). This type is shown

bordering the Katagum River at Sherifuri, north of Azare, in Plate xxi, fig. 1. *G. morsitans* also occurred in this particular instance.

(1) When so dense as to be almost impenetrable :—very scanty *tachinoides.*

(2) With open spaces below trees :—*tachinoides*, and, occasionally, *morsitans.*

(*d*) The "orchard" bush, a dry deciduous forest, generally very thin, with an undergrowth of long grass; often a secondary growth after farming; with most of the trees mentioned above which shed their foliage in the dry season :—*morsitans* locally in the rains and early dry season, a few *palpalis* and *tachinoides* close to their haunts, especially in the rainy season.

(*e*) The thorn forests of Kano, Sokoto, Bornu and eastern Bauchi Provinces; with such trees as *Anogeissus leiocarpus*, *Acacia* spp., *Adansonia digitata* (kuka), *Bombax buonopozense* (kuriya), *Combretum* sp. (geza), *Zizyphus jujuba* (magariya), *Balanites aegyptiaca* (aduwa), *Tamarindus indica* (tsamiya), *Boswellia dalzielii* (hano). The type is illustrated in Plate xxi, fig. 2, taken shortly after fire.

(1) Dense, near permanent, or almost permanent, water :—*tachinoides*, and, locally, *morsitans.*

(2) Thin and dry :—locally, *morsitans*; and rare stragglers of *tachinoides* (more numerous in the rains) near their haunts.

(*f*) Fadama : long-grass areas swampy in the rains, the only common tree being *Mitragyne africana* (giyeya) :—*morsitans* locally, and occasional individuals of the other species near their haunts.

## III.—Breeding Habits.

### 1. Glossina palpalis.

Although this fly is prevalent in many places that we have visited, it was really numerous only on the Niger at the end of the rains, on the larger rivers of Nassarawa, and on the Benue about Abinsi. Consequently searches for pupae revealed only small numbers. They were collected in 20 positions, in every case in sand, with or without vegetable debris overlying it. These were always very close to water. In 14 instances there was shrubby undergrowth above the pupae or closely backing the sand-bank in which they were found; twice (18 and 1 pupae respectively) they were below sloping tree-trunks; once (13 pupae) focussed around a small upright dead stump with thin shade 20 ft. above; and once (2 empty cases) very exposed with the scantiest of high shade above them. In 18 cases there was high thin evergreen shade and in two instances this was lacking, there being shrub shade only. The positions are thus quite similar to those described for this species in East Africa. Particularly favourable sites were the high sand banks thrown up where a small stream joins a larger one. In one such spot 140 pupae were collected by two searchers in a few minutes.

During the rains the searches failed to reveal any pupae beyond an occasional old case, all the normal breeding grounds being then inundated or water-logged. There was also a little evidence obtained by dissections that the rate of breeding is restrained in the height of the rains and at their close. In the late rains (September and October) out of 59 females examined only 13 (22 per cent.) were pregnant; while in the dry season (December, January, March) and early rains (April) out of 172 females dissected 117 (68 per cent.) contained larvae.

### 2. Glossina tachinoides.

The breeding habits of this fly are little known and will therefore be discussed in more detail.

### (*a*) *Breeding Haunts.*

Over 8,000 pupae and empty cases were collected and the breeding haunts appear to differ in some points from those of *palpalis*. The fly exhibits a preference for sand, the pupae being distributed as follows :—7,540 in coarse sand, 525 in fine sand, 113 in wood ash, 80 in cracks in baked mud, 8 in fibrous loam, and 2 in gravel. Selection was very marked once in the case of the buttresses of a fig tree ; one angle containing sand yielded about 300 pupae, and the other angles, floored by hard mud and filled in with leaves, none at all. The great majority, 7,970, were collected where the only shade was that of high trees, with no low growth ; 176 were collected in 14 positions from under shrubs or fallen trees overshadowed by high foliage ; 124 were taken in 5 positions where there was only the shade of low shrubs. There seems to be a well marked difference between *tachinoides* and *palpalis* in this, the latter having usually low shade above, or close to, its pupa sites. There was practically always some vegetable debris on the surface of the ground above the pupae, but it would be hard to find a spot in the *tachinoides* haunts where there was no such accumulation. There was no particular association with animal paths, but the situation of the breeding spots in open spaces in the forest amounts almost to the same thing. Mainly they were very close to water, but given satisfactory forest they may be very distant from it, since at Mashiwashi great numbers of pupae were taken out of a mile of stream-bed in which there were only two small water-holes close together. A few of the breeding sites deserve special mention.

1. High flat bank of Benue River : type (*c*) forest to edge of bank, with large open spaces ; heavy forest about 100 yards wide backed by type (*d*) forest ; moderate amount of game, many baboons and warthog, together with the river fauna available as food supply ; ground mainly a dry cracked mud mosaic ; mid dry season. Wood-cutters had pulverised about 25 sq. ft. of the mud into fine sand, very shallow with small cut branches lying over ; moderate shade 20 ft. above the site and no low bushes near ; yielded 59 pupae and 281 empty cases. Twenty feet away from this position in the same open space was an old camp fire with ash and charred sticks covering an area of 9 sq. ft., very shallow fine sand below the ash (mud pulverised by heat) ; 16 pupae and 97 cases were taken from the ash. Much of the mud mosaic was pulled up, but no pupae could be found in the cracks in this place. In the same locality in shallow sandy depressions along baboon paths 10 pupae and 8 cases were found.

2. At Patta, a town near the Gongola River, in Gombe Division : town watering place in a stream-bed ; type (*c*) forest in rocky gorge, the shaded part being about 200 yards long and 10 yards wide ; dry stony ground around ; two small deep pools forming the town watering place ; food supply practically only man and *Varanus*, and the latter could not be numerous ; late dry season. In a small patch of coarse sand in hollow of rock, overshadowed by larger rock, 10 pupae and 1 case. This position is under the big rock in the background in Plate xxii, fig. 1. A coarse sand accumulation in angle of buttresses of a fig tree (the straight white trunk in the illustration) and a strip of coarse sand between rock and bank together yielded 312 pupae and 406 cases. In a patch of sand, 2 sq. yards, among rocks over-shadowed by a large fig tree, 5 pupae and 251 cases were taken. This last breeding site was apparently being abandoned with the shedding of the foliage of the tree which overshadowed it (*cf.* Fiske's account of the destruction of *palpalis* pupae by sun when caterpillars defoliated the shade above them).

3. At Mashiwashi in type (*b*) forest, an area about 200 yards wide in its broadest part and about a mile long, narrowing away at its ends into fadamas ; bordered by type (*d*) forest ; dense thickets in parts, but with considerable open spaces and traversed by a sandy stream-bed containing water only in pools for most of the dry season. From 24.iv. to 15.v., in the early rains before the stream had commenced to flow, 6,217 cases and 124 pupae, of which 88 contained dead flies, were

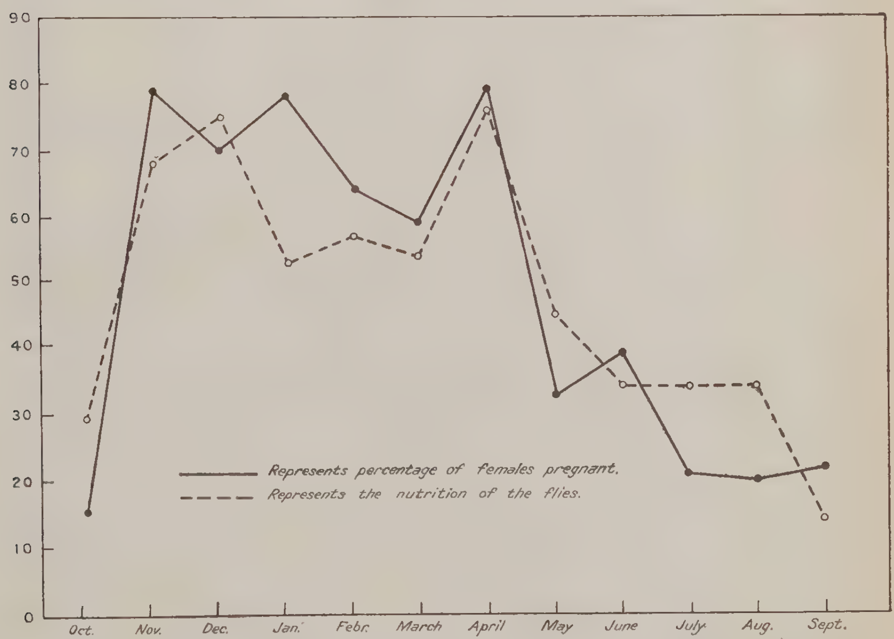
found. These were mainly concentrated in the wider parts of the bed and pupae were almost absent where this became narrow. The shade above them was high and moderately dense. This had undoubtedly been the main breeding ground in the dry season, the number of empty cases which were found in patches of sand outside the bed being negligible. A portion of this breeding ground is shown in Plate xxii, fig. 2.

Among the pupa-cases collected in this last locality a few of *palpalis* may be included, as this fly was present to the small extent of 0·7 per cent. among the *tachinoides*. A number of each species were bred out and the cases carefully compared, but no specific distinguishing characters could be found, differences in size and shape being unreliable.

### (*b*) *Breeding Season.*

After the middle of May at Mashiwashi all the sand became thoroughly wet and compact, and pupae or cases were not found except in insignificant numbers in sand and none in vegetable debris.

After this date a considerable, though much reduced, number must have been deposited, as was indicated by the pregnant condition of many of the females. We do not yet know where the pupae are deposited in the rains, but there is much evidence of a restraint in the breeding rate. Breeding in the rains seems uneconomical. There had already been a heavy storm when work was started at Mashiwashi, and, as stated above, of the 124 whole pupae collected from the stream-bed 70 per cent. contained dead flies, almost certainly killed by the wet, though the water did not




begin to flow until the end of June. Very prolonged searches by one of us in July 1921 (mid rains) in sand and other materials, in holes in trees and below fallen trunks failed to reveal any pupae or cases. A small artificial breeding ground on the stream bank (a patch of sand 6 ft. across with dry palm leaves over it, protected

from wet by a ditch and a thatched roof 4 ft above) constructed at the beginning of May yielded :—3rd–9th May, 3 *tachinoides* pupae ; 10th–15th May, 6 *tachinoides* pupae ; 16th–23rd May, 1 *palpalis* pupa ; all producing healthy flies. Up to the middle of July no more pupae were deposited there.

Apart from the above indirect and, it is admitted, slight evidence of the check in breeding, there is the more conclusive evidence obtained by the examination of the female flies. The figures which are shown in Table I and Diagram I were obtained from October to April by dissection, in May partly by dissection and partly by external examination, from June onwards by external examination only. The meteorological data were collected from the nearest recording stations to the areas where the flies were examined. In October, the last month of the rains, dry warm spells with intervening tornados, 16 per cent. of the females were pregnant. In the first three months of the dry season and in a much drier part of the country the pregnant females totalled 79, 70 and 78 per cent. respectively, the last figure being obtained from a very small number of flies. In February there is a fall to 64 per cent., and in March a further fall to 59 per cent., due in all probability to the increasing prevalence of recently emerged flies. In the first tornado month, April, the figure rises again to 79 per cent., but this coincided with a change to a locality where *tachinoides* was particularly thriving. From that month onwards in this same area there was a very considerable fall in the proportion of pregnant flies. As will be shown later, the variation in pregnancy may be correlated with a variation in the amount of food taken. That most of the breeding takes place during the greatest concentration of the fly is a point of practical importance.

TABLE 1.

*Showing the Seasonal Variation in Larva Production of G.* tachinoides, *and its Correlation with Nutrition.*

| Month. | Food content of gut. | | Pregnancy. | | Meteorological Data. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number of flies examined. | Percentage showing blood or much detritus | Number of females examined. | Percentage pregnant. | Recording station. | Rainfall in inches. | Temperature. Mean. | Temperature. Absolute maximum. | Temperature. Absolute minimum. |
| October, 1921 .. | 93 | 30·0 | 51 | 16·0 | Lokoja | 3·6 | 80·8 | 89·7 | 71·8 |
| November, 1921 .. | 199 | 68·0 | 107 | 79·0 | Zaria | *nil* | 70·6 | 90·0 | 46·0 |
| December, 1921 .. | 180 | 75·0 | 73 | 70·0 | Bauchi | *nil* | 77·0 | 97·0 | 50·0 |
| January, 1922 .. | 36 | 53·0 | 9 | 78·0 | Keffi | 0·14 | 79·5 | 100·0 | 54·0 |
| February, 1922 .. | 394 | 57·0 | 203 | 64·0 | Ibi | 0·79 | 83·4 | 104·0 | 57·0 |
| March, 1922 .. | 180 | 54·0 | 54 | 59·0 | Bauchi | *nil* | 84·4 | 107·0 | 63·0 |
| April, 1922 .. | 100 | 76·0 | 52 | 79·0 | Zaria | 1·86 | 76·7 | 96·0 | 55·0 |
| May, 1922 .. | 316 | 45·0 | 2,032 | 33·0 | Mashiwashi | 3·21 | 80·8 | 100·0 | 68·0 |
| June, 1922 .. | 100 | 34·0 | 2,830 | 39·0 | ,, | 6·12 | 76·1 | 87·0 | 67·0 |
| July, 1922 .. | 100 | 34·0 | 2,722 | 21·0 | ,, | 5·5 | 74·8 | 84·0 | 67·0 |
| August, 1922 .. | 100 | 34·0 | 2,417 | 20·0 | ,, | 14·0 | 73·8 | 83·0 | 67·0 |
| September, 1922 .. | 100 | 14·0 | 3,361 | 22·0 | ,, | 14·6 | 75·9 | 85·0 | 67·0 |

### 3. Glossina morsitans.

We have paid no special attention to the breeding haunts of this fly, as we have spent only short periods in places where it was numerous. Its pupae were found in association with those of *tachinoides* at Dau (Gombe Division) in sand below bushes, and again in the stream-bed at Mashiwashi to the number of 82.

## IV.—The Sex Ratio in *G. tachinoides*.

It is well known that with *palpalis, morsitans* and *brevipalpis* in a catch of fly the males are usually greatly in excess of the females. When the natural fauna of an area is reduced the proportion of females rises to 50 per cent., or even higher, with *palpalis* and *morsitans*, while no data on this point have yet been collected for *brevipalpis*. This simply means that the majority of the flies which investigate man are males seeking mates and not particularly desirous of feeding, but that when natural food is scarce the females are more driven to him in a search for food —their hunger compelling them to miss no chance of a meal. The accumulated males which accompany moving man or animals are known as "following swarms." No such following swarm has been seen with *tachinoides* about either man or domestic animals, and every fly that comes seems to be desirous of feeding. Even those which contain recently drawn blood are quite ready to imbibe more if they are not full to repletion. At the same time there is no general preponderance of males in the catches. In a total of 14,400 flies examined from all localities the female percentage is 46. Of these 12,000 were taken at Mashiwashi and Maalo, a village six miles further west, and the female percentage was also 46. In the latter areas the population is scanty and there is a large natural fauna, so that if *tachinoides* behaved like the other species the female percentage should be low, as that of *morsitans* is in the same areas (exactly 10 per cent. females in 364 flies examined). After comparing the female percentages in catches taken in 60 localities with the food available, mammals and reptiles, and the estimated nutrition of the fly as found by examination of the gut contents, no relation between varying sex proportions and the hunger of the fly can be found. There would be no useful purpose served in describing special cases, as the figures constantly contradict the accepted views of sex proportion in tsetses. The conclusions which may be drawn are :—(*a*) the mating habits of these flies differ from those of the other species whose habits are known, the males not needing to make a following swarm in order to secure mates ; (*b*) *G. tachinoides* likes man as a host quite as well as any other animal, and this conclusion was reached from another point of view.

## V.—Food of Tsetse-flies.

### 1. Glossina palpalis.

In the dissection of 552 recently caught flies in various localities it was found that 96 contained recognisable blood which was mammalian in 75 (78 per cent.) and non-mammalian in 21 (22 per cent.). This proportion was found to be about the same where game was present or almost absent (*see* Table III). As in Uganda, the source of the nucleated red cells was probably crocodiles and *Varanus*, the monitor lizard, the latter being plentiful in most of the *palpalis* haunts. The catches made were always too small to show any relation between the female percentage and a natural food supply as opposed to man or domestic stock. Out of 21 localities, in which at least 15 flies were caught, crocodiles were present in 11 and the average female percentage was 42 ; game animals were tolerably plentiful in 12 and the average female percentage was 40 ; there was close contact with domestic stock in 8 and the average female percentage was 40 ; man was in close contact with the fly in 19 and the average female percentage was 42. These figures are enough to show that generally in the Northern Provinces the fly looks to man, when available, for a proportion of its food, but the territory is on the outskirts of the *palpalis* country and atypical conditions are therefore not surprising.

In two localities where *palpalis* was found, cattle, sheep and goats were grazing to such an extent that practically all other mammalian hosts were excluded, these being (1) from Lemmi to Taura on the northern face of the Bauchi Plateau, a large stock-raising district ; and (2) at Tilde Filani, also at the foot of the plateau but more to the S.E., a description of which is given on page 383.

## 2. Glossina tachinoides.

### (a) *Habits.*

As already indicated, the food of *tachinoides* is a matter of considerable interest. It attacks man with great avidity, attempting to feed almost invariably on the ankles or on a part of the body close to the ground when the victim is stooping or sitting. It similarly attacks the fetlocks of quadruped mammals, which are seen to be constantly stamping in a *tachinoides* haunt. *G. palpalis* has this habit of low attack to a less extent, and *morsitans* not at all. *G. tachinoides* is undoubtedly the most wary of the three species and can fill itself with great rapidity. It rarely takes food into its crop, whereas *morsitans*, if given the opportunity of an undisturbed meal, almost invariably fills both gut and crop. When replete it always seems to fly upwards and settles on a trunk or branch to drain off the excess of fluid. It is most active in the sun hours, but attacks before sunrise and after sunset and sometimes during the night.

### (b) *Fauna in* tachinoides *Haunts.*

In considering the fauna with which this fly comes into contact its haunts may be divided into three sections.

Firstly, on the banks of the great rivers, such as the Niger and the Benue, it has access to *Varanus* and to crocodiles, but as regards the latter to a less extent than obtains with *palpalis*, since where *tachinoides* is most prevalent, on the mid-Benue, these animals very definitely avoid the shaded banks in the dry season and almost invariably bask on the bare sand-banks far out in mid-stream, out of reach of the fly. The smaller antelopes and pig are generally prevalent, together with kob (*Cobus kob*). Larger antelopes and buffalo are present, but not numerous, as they keep well away from the river bank. Hippopotamus are present locally and the manatee is rather numerous in places, but its habits are very obscure. Baboons are extremely numerous and on the river banks probably outnumber any other large mammal. There is close contact with man in fishing creeks and where wood cutting is carried on. There are no cattle, and the few sheep and goats are confined to the villages, but there is a large traffic of sheep and goats by canoe down-stream on the Benue and some food may be obtained from these at halting places.

Secondly, in the forests which contain pools in the dry season and in the shaded parts of non-permanent streams, where the population is scanty, *Varanus* is generally present, but crocodiles only in isolated cases. Game animals, large and small, are always present in inverse proportion to the amount of native hunting. Pigs and baboons are nearly always present. Cattle are absent and sheep and goats are rarely available except at river crossings. Contact with man is variable, but generally slight. In the forest at Mashiwashi, which comes into this class, and where *tachinoides* seemed to be living under optimum conditions, judging by its numbers and individual size, there were no crocodiles or water *Varanus* (in the dry season, at any rate), no baboons and no carnivorous animals larger than a wild cat. Small monkeys of at least two species were numerous. There were also present bushbuck and red-flanked and common duiker in some numbers, while warthog, hartebeeste and roan antelope moved sometimes along the outskirts. There was a small village in the heart of the forest inhabited only in the dry season, the natives living away on farms for the rest of the year. There were no domestic animals. Among 316 flies dissected here no non-mammalian blood was seen in the 42 guts in which blood was recognisable.

Thirdly, there are the shaded pools and small rivers in the densely populated parts of the country to be considered. *Varanus* is present, but no crocodiles, except in isolated instances, of which one was encountered near Gwaram—an extraordinary deep pool, farmed on both sides, where these reptiles abounded. Game animals and pigs are reduced to negligible proportions, while the larger antelopes are totally

absent, and, generally also, baboons. Small monkeys are usually present. Cattle, sheep and goats abound, and man comes into close relation with the fly, as the farms often abut on the fly areas.

It is, of course, possible that *tachinoides* has some wholly unexpected hosts, such as birds or fruit-bats, which are common in many of its haunts, but there is no evidence of this at present.

### (c) *Colonies of* G. tachinoides *in Populous Districts.*

The third condition mentioned in the last section deserves fuller consideration, since the existence of the fly in such areas is a very important matter. The colonies of the fly in these are generally small, but the forest conditions are not good, farming having reduced the shade to very small proportions. However, several thriving colonies of the fly under these artificial conditions have been examined. On the River Kudu in South Kano in a densely populated part on the main Kano-Nafada road, where the banks of the stream are tolerably broadly shaded, six very inexpert fly boys caught flies at the rate of 20 per boy-hour (*cf.* Fiske)—a large catch of this very agile fly. At Patta, in the locality described above (page 378), a shaded village water-hole, entirely isolated by very dry bush, the catch of fly was at the rate of 40 per boy-hour, and 982 pupae were collected in under two hours. A few monitor lizards were present, but to the best of our knowledge no other animal visited the spot except that there was a constant procession of women fetching water in the morning and evening. The domestic animals did not water here. Out of 80 flies dissected from this spot 18 contained recognisable blood, which in two cases was reptilian and in 16 cases was indistinguishable from that of man. This was one of the densest colonies of *tachinoides* we encountered, though of small extent, and it was distressing to work in it on account of the persistent attacks of the flies. A third instance of a similar condition was found at Tilde Filani, on the upper waters of the Katagum River, in Bauchi Province. Tilde is a large, scattered, cattle-raising town in a broad valley surrounded by rocky hills. The whole of the floor of the valley is now, or has been recently, farmed and the shade is restricted to a small rocky part of the stream-bed, which is in a shallow ravine. The stream was flowing above ground in places in March, when we visited it. A thriving colony of *palpalis* was found in the shade at the watering place, and with them a few *tachinoides* were caught. Some monitors were present (reptilian blood was found in one *palpalis* to eight which contained mammalian blood), but apart from these there was no observable source of food except man and domestic stock.

### (d) *Some Contrasts with* G. morsitans.

Two localities visited gave a marked contrast in the nourishment of *tachinoides* and *morsitans.*

The first of these was on Baro Hill (Niger River) at the end of the rains in October. The sides of the plateau are densely bushed, while the top is covered for the most part by very long grass on the site of the old Government station, by farmed land, and in places by patches of moderately dense deciduous forest. *G. tachinoides* was taken around the foot of the hill and in the forest in association with *morsitans*, and on the slopes by itself. Some large antelopes were present, together with bushbuck and duiker. Baboons were rather plentiful. Wood-cutters worked in places on the edge of the plateau in sufficient numbers to form small paths. There were no cattle. Aquatic reptiles are of no account, as there is never any surface water on the hill, which is of laterite rock and absorbs the rain as it falls. In all, 120 *tachinoides* were caught, of which 74 were dissected ; of these 9 contained blood, all mammalian, and 74 per cent. contained only the merest trace of detritus in the gut ; the flies had thin wafer-like abdomens and practically no development of fat. Of 48 *morsitans* obtained, 45 were dissected ; of these 12 contained blood, all

mammalian, and 47 per cent. contained only the merest trace of detritus; the flies were well nourished and showed a great development of fat; the female percentage was 16·6, indicating no particular hunger in the fly. This forms an instance where the two species have access to the same food supply at a time when the grass is long and green, and the advantage is decidedly with *morsitans*.

The second instance was at Dau (Gombe Division) towards the end of the dry season in March. This fly area is a wide flat valley with type (*b*) forest, very small permanent pools and open spaces. Large and small antelopes and pig were plentiful in the district, which was a good deal hunted by the natives. Baboons were very numerous. It is improbable that the water *Varanus* was present, crocodiles certainly were not. There was a farm close by, but it was temporarily deserted, as the crops were all gathered and removed. The sporadic visits of the hunters gave the only chance of human blood, and there were no domestic animals. A severe fire had just passed through and the cover of the game had been largely destroyed. The antelopes seemed to be feeding on the higher ground, where there was much spoor, and passing through the valley, its normal abode, only at night, but the tsetse remained in the shady valley. The baboons were there all day. We caught 177 *tachinoides* and 80 were dissected; of these 7 contained recognisable blood, all mammalian, while only 36 per cent. of them contained a small quantity of detritus; they were well nourished and showed a good development of fat. Of 149 *morsitans* obtained, 71 were dissected; of these 6 contained recognisable blood, all mammalian, while 57 per cent. of them contained only a small quantity of detritus; they were thin and showed little development of fat; the female percentage was 43·6, indicating hunger. In this case it seemed to us certain that *tachinoides* was feeding on the baboons to an extent that the less agile *morsitans* was unable to do and that the latter, deprived of its normal food temporarily, was consequently starved.

A further contrast between the food of these two flies was brought out in the dissections. Notes were kept as to whether the recognisable mammalian blood contained the small red cells, such as occur in the blood of most antelopes, cattle, sheep and goats, or the large type of red cell which occurs in man and most other mammals. No measurements were made, as the task would have been too great, but a constant picture of the difference in size was before the eye owing to the frequent occurrence of both types. The figures are given in Table II and show that the large type of red cell was found twice as frequently in *tachinoides* as in *morsitans*, and the small type occurred five times as frequently in the latter as in the former. This further shows that *tachinoides* is less closely associated with the antelope class than is *morsitans*, and other evidence of this is given later (page 390).

TABLE II.

*Contrasting the Type of Mammalian Blood found in Flies dissected, and the Proportion infected with Flagellates.*

| Species. | Number of flies examined. | Number with recognisable mammalian blood. | Percentage containing red cells of | | | Percentage of total flies infected with flagellates. |
|---|---|---|---|---|---|---|
| | | | Large type. | Small type. | Indeterminate type. | |
| *G. morsitans* .. | 500 | 93 | 42·0 | 56·0 | 2·0 | 26·4 |
| *G. tachinoides* .. | 1,500 | 195 | 85·0 | 11·0 | 4·0 | 11·3 |
| *G. palpalis* .. | 552 | 75 | 55·0 | 25·0 | 20·0* | 5·6 |

* From early figures—probably mostly large type.

### (*e*) *Evidence of Choice of Diet in* G. tachinoides.

As with *morsitans*, observations on the feeding habits of *tachinoides* in nature are difficult on account of the shyness of the wild animals and the great counter-attraction which the observer makes. Their main haunts are too dense for European methods of hunting, so that large mammals are rarely shot in the presence of the fly. We have found only one definite instance of *tachinoides* feeding on a game animal, and this case was a waterbuck which was wounded in open country and, going into close forest, entered a pool, where it was killed. *G. tachinoides* had assailed it in numbers, 14 being caught in three sweeps of the net, 7 ♂ and 7 ♀, the proportion showing that the flies did not form a following swarm but a feeding group. They have often been seen feeding upon goats and dogs.

Laboratory experiments showed that they feed very readily on the tortoise, when released in a cage with it, drawing blood from the neck and under the carapace near the tail, but the very large blood cells of this animal have not been met with in the dissected flies. They also fed freely and repeatedly on a chameleon in a cage, the animal not molesting them and appearing indifferent to their attacks. In nature the fly certainly feeds on some reptile and almost certainly this is mainly *Varanus*, judging by the localities where this type of blood has been most frequently found in the flies. A haemogregarine was occasionally seen with the nucleated red cells in the flies, and this is a characteristic blood parasite of *Varanus* and crocodiles, but not of birds.

In a total of 1,500 flies examined 232 contained recognisable blood, non-mammalian in 37 cases (16 per cent. of the total). The occurrence of non-mammalian blood was thus four times as frequent in *tachinoides* as in *morsitans* (4·1 per cent.), but less frequent than in *palpalis* (22 per cent.) for the whole range of examinations. When the localities from which the flies were dissected are divided into two classes according

TABLE III.

*Showing the Proportion of Non-mammalian to Mammalian Blood in the three prevalent Species of Tsetse-flies in the presence or virtual absence of Game.*

(A). Game virtually absent.

| Species. | Number examined. | Number containing recognisable blood. | Number containing nucleated blood. | Percentage of nucleated blood. |
|---|---|---|---|---|
| *G. palpalis* .. .. | 370 | 70 | 16 | 22·9 |
| *G. tachinoides* .. | 407 | 83 | 22 | 26·5 |
| *G. morsitans* .. | Not encountered | — | — | — |

(B). Game present.

| Species. | Number examined. | Number containing recognisable blood. | Number containing nucleated blood. | Percentage of nucleated blood. |
|---|---|---|---|---|
| *G. palpalis* .. .. | 182 | 26 | 5 | 19·2 |
| *G. tachinoides* .. | 1,093 | 149 | 15 | 10·1 |
| *G. morsitans* .. | 500 | 97 | 4 | 4·1 |

to the presence or virtual absence of game and, of course, other large wild animals, such as baboons, an interesting difference occurs, which is too pronounced to be accidental. The nucleated blood in *tachinoides* is more than twice as plentiful where game animals and baboons are almost totally absent as where these are present in some quantity, and this seems to indicate a preference for mammalian blood (see Table III). With *palpalis*, a fly which it has been amply proved has a preference for reptiles as prey, the proportion is about the same in both cases. In this connection it should be pointed out that there can be no specially large numbers of *Varanus*, the only large reptile concerned, in the densely populated parts as opposed to the less populous areas. The animal is much esteemed as food and is greatly hunted, and the only reason it survives in the densely populated districts is that it is a particularly shy elusive creature.

### (*f*) *Seasonal Variation in Nutrition.*

In the course of the dissections a variation in the gut contents of the flies was observed which could be correlated with the season of the year. When the fly contained only a trace of detritus in the gut just anterior to the Malpighian tubules, it was considered to be in a very hungry state. Under this heading recently emerged flies which had not fed were necessarily included, as there is in them a small trace of detritus in this position and the gut contents in only two or three cases could be described as nil. The fact that the data are collected in different districts rather detracts from their value, but the records from the nearest Meteorological Recording Station have been collected for the various months and are given in Table I. The record begins in October on the Niger at the end of the rains, when tornados are still occurring and the grass is high and green. In this month 30 per cent. of the flies examined had recently fed, "recently" being broadly interpreted. The figures for November were obtained in Zaria and South Kano Provinces, a much drier part of the country, so that there is really more than a month's interval between as regards the state of the season. The grass was dry and in some places burnt, while the undergrowth in the forests was dying down. Of the flies examined, 68 per cent. had recently fed. In the next month near the same locality, much of the grass having been burnt off, the percentage rose to 75 per cent. The next three months' figures are obtained from the Benue River and mid Bauchi Province in the middle and late dry season, when the grass was largely burnt off and the undergrowth had died down. Breeding was known to be actively in progress and many young flies are included in the figures. The percentage of recently fed flies are: January, 53 (from a very small total); February, 57; March, 54. The figures for the rest of the twelve months are taken from the flies caught in the heavy forest area at Mashiwashi, where, as stated above, *tachinoides* appeared to be under optimum conditions. In April, the first month of the rains, in which there were two storms only, 76 per cent. of the flies examined had recently fed. At this time the floor of the forest was still very open, as the creepers and herbaceous plants were just beginning to sprout. In May, the figure falls rapidly to 45 per cent. of recently fed flies, and in June to 34 per cent. In these months the undergrowth in the heavy forest was becoming denser, especially in its outskirts, and the grass along its edge became waist-high. So far as vegetation was concerned the conditions near the Niger in October were being approached. Our presence seemed to disturb the fauna in the forest very little, and there was still abundant spoor of bushbuck and red-flanked duiker there. At the beginning of our time at Mashiwashi large antelopes visited the edge of the heavy forest occasionally. These visits ceased in May, but there was no reason for them to continue, as conditions were then better for these animals on the higher ground.

We obtained no evidence that the flies are less eager to feed in the rainy season when they reach a host. In dull weather they do not move about much and so

there is less opportunity, in that there is less time for them to feed, but the dull weather did not begin until the middle of June, the early tornado season like the late one at the end of the rains being mostly very sunny. The most reasonable explanation of this falling away in nourishment in the rains seems to be that food is more difficult to find by *tachinoides* with its low flight owing to the high undergrowth, and perhaps to some extent that its food is less concentrated.

The point has been developed at some length because this starved condition of the flies during the rains corresponds with the restraint in breeding mentioned above (see Diagram I) and is possibly the explanation of this. Fiske gives an instance with *palpalpis* where a great increase of the fly on an island in Victoria Nyanza led to a relative reduction of food supply and a consequent reduction in breeding. In this case of *tachinoides*, however, it is not certain that this reduction in nourishment is wholly the cause of the restrained breeding, since it would seem economical that a long-lived insect like the tsetse in a country where there is a prolonged dry season should not breed in the rains, when many of its pupae must inevitably perish and its young emerge under adverse conditions.

### (g) *Conclusions on Food* of G. tachinoides.

The conclusions drawn are :—

1. *G. tachinoides* prefers a mammalian host, and its greater agility gives it a wider range of potential hosts in this class than *morsitans* has.
2. It is not particularly associated with antelopes, but feeds on them to a moderate extent.
3. It draws a considerable proportion of its food from reptiles, especially where wild mammals are scarce.
4. It is a very adaptable fly as regards its food and can thrive in densely populated districts where the wild fauna is reduced to as small proportions as it conceivably could be in tropical Africa.
5. It finds its food more readily in forest with areas free from undergrowth and is consequently better nourished in the dry season than in the rains.

## 3. **Glossina morsitans.**

Observations made on this fly are in agreement with the generally accepted views as regards its food. It was never met with in the absence of big game, though in some cases, notably at Shellim (Azare Division), this was excessively scanty. However, the presence of any large antelope indicates a considerable number of small antelopes and pigs, since the large mammals are driven out or exterminated before the latter approach extinction. At the same time there are large areas of bush in the Northern Provinces which form good game country where *morsitans* is not found, though the bush appears suitable for it. Wherever it was encountered, with the solitary exception of Dau, quoted above (p. 384), it was in a well adjusted balance with its food supply, since the percentage of females in the catch was always rather low, varying from 3·5 to 28 per cent. for catches of over 20 flies. We were seriously pestered ourselves in only three out of the 47 localities where the fly was met with, viz. (1) at Dau ; (2) at Sherifuri (Azare Division) in thorn forest, the grass of which had just been burnt off ; (3) in spots around Mashiwashi, which is on the eastern edge of a *morsitans* area in which the fly is very abundant. This species does not have much opportunity of feeding on domestic stock, except in the few instances where cattle roads pass near its haunts, since the stock owners recognise its areas as unhealthy to their animals, though they do not associate the evil with the fly. In consequence of this the 56 per cent. of small type mammalian blood (the blood of pigs being included among the large type bloods) found by dissection (see Table II)

has more significance than the 25 per cent. and 11 per cent. given for *palpalis* and *tachinoides* respectively, since much of the latter is known to be drawn from cattle and goats. Undoubtedly *morsitans* draws the bulk of its food from antelopes and pigs. Non-mammalian blood was found in four cases out of 97 recognisable bloods, as usual, a very small proportion.

## VI.—Trypanosome Infections in Tsetse-flies.

This section deals with a part of the investigation which is at the time of writing very incomplete, but a brief account of it is essential for the purposes of this report. A preliminary examination of the stained slides was made as the material accumulated, but a more critical study of these could not be carried out until a large number had been collected. This critical examination is now in progress and a fuller account will be issued when it is complete.

Flies of the four species met with were dissected. The living fly was held between the finger and thumb, and gentle pressure was applied from behind forwards until the proboscis was depressed as in the act of feeding. A needle was then placed on the front of the head and in most cases a small drop of salivary fluid appeared at the tip of the proboscis. This exudate, called the "salivary drop," was received on a slide with a smearing motion. The fly was then dissected, the salivary glands, proventriculus, gut and proboscis (with a note about the hypopharynx) were mounted and examined separately. Any organs containing flagellates were transferred to a small drop of saline on a clean slide, teased up, dried rapidly, fixed with absolute alcohol, and stained with Giemsa's stain, 12–18 hours in a 2–3 per cent. solution. Thanks mainly to the work of the Royal Society's Sleeping Sickness Commissions, especially the one in Nyasaland under Sir David Bruce (4), it is possible to refer the tsetse-borne pathogenic trypanosomes to the three main groups when the infection in the fly is mature. This is done partly by their position in the fly and partly by the morphology of the infective forms, which resemble blood forms and are group-specifically distinct. Briefly, the *brucei-gambiense* group develop in the gut, pass forward to the proventriculus and so to the salivary glands, where the infective forms are found; the proboscis plays no part in their development. The *pecorum* group also develop in the gut and pass forward to the proventriculus and proboscis, the infective forms being found in the hypopharynx, and the salivary glands being not involved. The *vivax* group is confined in its development to the proboscis, the infective forms being found in the hypopharynx. There is also the possibility that non-pathogenic forms, such as *T. grayi* found in the gut of *palpalis*, may be encountered, while an infection of gut and proboscis in a wild fly, if judged only by position, might be due to a double infection with the *vivax* group and one of the gut developing forms, or it might be a pure *pecorum* group infection. These facts detract from the value of the almost entirely statistical data which we are at present able to give.

The results obtained by means of the salivary drop were disappointing. It was hoped that it would be a simple and rapid method of finding infective flies, but this proved not to be the case. The amount of material exuded was uneven, and when a large smear was obtained it was impervious to stain, the trypanosomes appearing like ghosts in a dark matrix, with nuclei, undulating membrane and flagellum faintly indicated. This difficulty may be overcome by receiving the salivary drop in a small drop of serum, when very good fixation and staining is obtained. Moreover, many infective flies were found by dissection, as indicated by the presence of the infective forms of trypanosomes, in which none were extruded on the slide. Nevertheless many infective forms belonging to the *pecorum* and *vivax* groups were thus obtained, and the method of examination, similar to one employed by Bruce, is not without its value, though of no use for statistical purposes.

No mature infection of the *brucei-gambiense* group has been met with in dissection, but a member of the group has been recovered from wild *G. tachinoides* by feeding freshly caught wild flies on a healthy dog at Mashiwashi.

*T. pecorum* and a member of the *vivax* group, probably *T. vivax*, have been definitely identified both in salivary drops and in proboscides in several *G. palpalis*, and in many instances in *G. tachinoides* and *G. morsitans*. Both *T. pecorum* and *T. vivax* have been recovered from *G. tachinoides* by feeding freshly caught wild flies on sheep at Mashiwashi.

Of 552 *palpalis* examined, trypanosomes were found in 31, distributed as follows: mid-gut only, 16; gut, proventriculus and proboscis, 3; proboscis only, 12. (Table IV.)

Of 1,500 *tachinoides* examined, trypanosomes were found in 170, distributed as follows: mid-gut only, 72; gut, proventriculus and proboscis, 16; proboscis only, 82. (Table IV.)

Of 500 *morsitans* examined, trypanosomes were found in 132, distributed as follows: mid-gut only, 26; gut, proventriculus and proboscis, 30; proboscis only, 76. (Table IV.)

Of 14 *longipalpis* examined, trypanosomes were found in the salivary drop of 1, these being ghost-like as described above but morphologically resembling the infective forms of *T. vivax*, but not certainly identified as such.

TABLE IV.

*Showing the Proportion of* G. palpalis, tachinoides *and* morsitans *infected with Trypanosomes, and their Situation in the Flies.*

| Species. | Number dissected. | Number showing trypanosomes | Total percentage infected. | Situation of trypanosomes in the flies (percentages). | | |
|---|---|---|---|---|---|---|
| | | | | Gut only. | Gut and proboscis. | Proboscis only. |
| *G. palpalis* .. | 552 | 31 | 5·6 | 2·9 | 0·5 | 2·2 |
| *G. tachinoides* .. | 1,500 | 170 | 11·3 | 4·8 | 1·1 | 5·4 |
| *G. morsitans* .. | 500 | 132 | 26·4 | 5·2 | 6·0 | 15·2 |

Wherever *morsitans* and *tachinoides* were found together, a series of each species was dissected in order that their infections and food might be contrasted. The total percentage of flagellate infections in 663 *tachinoides* was 12, and that in 471 *morsitans* was 25. These data are collected from six different localities, each of which gives much the same result, viz., that when the two species are found in the same area the flagellate infections of *morsitans* are about double those of *tachinoides*.

Table V further contrasts these infections in the two species, all that were examined being included, and *tachinoides* being divided into two classes according as to whether they were collected in areas where big game is absent and small game virtually so, or in areas where big game was present and small antelopes and pig correspondingly numerous. The infections are classified according to the location of the trypanosomes in the fly. In the populous districts with scanty small game but numerous domestic animals *tachinoides* shows a heavy percentage of gut infections, with few in the proboscis. In the game areas the infections of the gut only

are relatively light, but the infections indicating the *pecorum* and *vivax* groups are respectively nearly three and four times as great as in the minimum game areas. *G. morsitans* compared with *tachinoides* in the game areas shows more infections of gut only, four times as many infections indicating the *pecorum* group, and twice as many indicating the *vivax* group. Evidence was given above (see Table II and p. 384) that *tachinoides* obtains a smaller proportion of its food from the game animals than does *morsitans*, and this is further evidence, since it must be admitted that the main source of the tsetse-borne pathogenic trypanosomes of domestic stock is to be found in the wild game.

TABLE V.

*Contrasting the Prevalence of Flagellates in* G. tachinoides *and* G. morsitans *in areas where Large Game is absent or present.*

(A). In absence of large game.

| Species. | Number examined. | Percentage showing flagellates in :— | | | Total percentage infected. |
|---|---|---|---|---|---|
| | | Gut only. | Gut and proboscis. | Proboscis only. | |
| *G. tachinoides* .. .. | 407 | 9·3 | 0·5 | 1·7 | 11·5 |
| *G. morsitans* .. .. | Not encountered | | | | |

(B). In presence of large game.

| Species. | Number examined. | Percentage showing flagellates in :— | | | Total percentage infected. |
|---|---|---|---|---|---|
| | | Gut only. | Gut and proboscis. | Proboscis only. | |
| *G. tachinoides* .. .. | 1,093 | 3·1 | 1·3 | 6·8 | 11·2 |
| *G. morsitans* .. .. | 500 | 5·2 | 6·0 | 15·2 | 26·4 |

## VII.—Relation of Tsetse-flies to Domestic Stock.

The value of the domestic stock of the Northern Provinces of Nigeria is very considerable. The estimated numbers of the various animals in 1920 were as follows: horses, 132,000; cattle, 2,400,000; sheep, 2,060,000; goats, 3,820,000; donkeys, 352,000; camels, 4,146; swine, 44,000. The presence of tsetse-flies among these is an important matter, as, apart from the numerous deaths due to trypanosomiasis, much of the best grazing country is closed to the stock-owners on account of tsetse. In many places they are confined to dry areas where the grazing is poor for a large part of the year and where they are watered from deep wells, when only a few miles away is an area of excellent grazing with permanent surface water which it is fatal to enter. At Gadam, for instance, in Gombe Division, cattle were so numerous as to have beaten down the whole of the dry grass within a mile or two of the town, and gathered in immense numbers at the scanty wells,

where water was drawn for them hand over hand in gourds. At Dau, eight miles away, there was abundant surface water and excellent grazing. Passing up the Benue in the tsetse areas to a point below Dau no cattle are seen except a very few slaughter cattle at Ibi, but from this point to Numan they are gathered literally in thousands on the sand-banks at night. The tsetse prohibit the natural expansion of the stock industry and it is important to estimate the relative culpability of the prevalent species.

Table VI shows the number of localities in which the three prevalent species of tsetse have been encountered alone or in combination, and an indication of the relative quantities of game and cattle in these.

*G. morsitans* has been found alone, or with one or both of the other species, in 47 localities, and cattle are noted as being present in one of these and very numerous in two ; these latter being on one of the main roads from Sokoto along which slaughter cattle are driven south, and there are few if any resident cattle in them. Several localities where a single individual *morsitans* was taken are omitted, as these were all close to large *morsitans* areas and the flies were clearly stragglers. Large game is absent in none, scanty in 13, numerous in 34.

*G. tachinoides* alone has been found in 32 localities ; cattle are absent in 17, but 9 of these are on the Benue River in places very close to the *morsitans* belts, with which cattle brought to the river must come in contact ; they are present in 6 ; numerous in 4 ; and very numerous in 5, all of these being resident cattle. Large game is absent in 16 ; scanty in 2 ; numerous in 14. Game of any sort is virtually absent in 3.

*G. palpalis* alone has been found in 36 localities ; cattle are absent in 17 ; present in 3 ; numerous in 4 ; very numerous in 12, 4 of which contain resident cattle and 8 are on the Sokoto road mentioned above. Large game is absent in 18 ; present in 12 ; numerous in 6.

*G. tachinoides* and *G. palpalis* together in the absence of *morsitans* have been found in 8 localities ; cattle are absent in 7, 4 of these being on the Benue close to the *morsitans* belts ; very numerous in one, these being resident herds at Tilde Filani in close contact with the flies, but in absence of game large or small. Large game is absent in 2 (small game also absent) ; present in 2 ; and numerous in 4.

These findings as regards cattle and *morsitans* agree with those of Macfie in Ilorin Province (1).

The combination *morsitans* and game is practically prohibitive to domestic animals. In fact the natives do not attempt to keep cattle in most of the *morsitans* country, giving some fantastic reason for avoiding it. There is no reason to suppose that the *morsitans* areas are extending in the country, and since they are avoided it is possible that this fly does not cause very much direct loss to the cattle owners, except among animals being driven to slaughter, which often die by the wayside. The indirect loss due to the closing of the best country is great.

Where *tachinoides* is found in the presence of big game the proportion of flies which contain trypanosomes in their proboscides (*i.e.*, the main stock-infecting trypanosomes) is considerable, and, as this fly is not avoided, like *morsitans*, being not prohibitive to stock, it is believed that it causes more direct loss than the prohibitive species when the cattle make their annual treks in search of better grazing and water. Even in the heart of the cattle country a considerable proportion of the *tachinoides* are infected with these trypanosomes, and the infected cattle doubtless keep up this proportion.

From the data obtained it would be difficult to say whether *G. palpalis* ranks above or below *tachinoides* as an infector of cattle, but its limited haunts in the country compared with the wide range of the smaller species leaves no doubt at all but that the latter is the more harmful fly in the aggregate.

TABLE VI.

*Showing that* G. morsitans *is more inhibitory to Cattle than* G. palpalis *or* G. tachinoides, *and its Association with Game.*

| *G. morsitans* | *G. tachinoides* | *G. palpalis* | Number of localities. | Large game. | | | Small game. | | | | Cattle. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | − | + | ++ | − | + | ++ | +++ | − | + | ++ | ++ |
| + | | | 25 | 0 | 3 | 22 | 0 | 1 | 23 | 1 | 24 | 1 | 0 | 0 |
| + | + | | 10 | 0 | 3 | 7 | 0 | 3 | 6 | 1 | 9 | 1 | 0 | 0 |
| + | + | + | 4 | 0 | 3 | 1 | 0 | 3 | 1 | 0 | 4 | 0 | 0 | 0 |
| + | | + | 8 | 0 | 4 | 4 | 0 | 4 | 4 | 0 | 6 | 0 | 0 | 2* |
| | + | | 32 | 16 | 2 | 14 | 3 | 12 | 17 | 0 | 17† | 6 | 4 | 5 |
| | + | + | 8 | 2 | 2 | 4 | 2 | 2 | 4 | 0 | 7‡ | 0 | 0 | 1 |
| | | + | 36 | 18 | 12 | 6 | 0 | 29 | 7 | 0 | 17 | 3 | 4 | 12§ |

Notes—* Trekking cattle.
† Nine of these on R. Benue backed by *morsitans*.
‡ Four of these on R. Benue backed by *morsitans*.
§ Eight of these trekking cattle.

## VIII.—Sleeping Sickness.

Sleeping sickness is endemic over a large part of the Northern Provinces of Nigeria. The Annual Medical Returns give a totally inadequate figure for the yearly incidence of cases, as sporadic native cases are not diagnosed except in Government stations, and local epidemics are infrequently diagnosed owing to the difficulty of a medical officer being spared to investigate them.

Ten cases in Europeans have been recorded during the past 11 years, 5 of which occurred in Nassarawa Province, 2 in Kabba Province, 2 on the River Benue, and 1 at Kaduna. The high incidence in Nassarawa is explained by the fact that the sufferers have been mining engineers whose work leads them to camp close to tsetse-infested streams, usually in proximity to a camp of native labourers.

Reports of limited epidemics among natives are frequently received from political officers, but these, as explained above, cannot always be investigated. The usual history obtained is as follows :—a few natives from a town or village decide to farm new ground, and naturally select a site in close proximity to a stream ; the farm extends and in a year or two a small village has sprung up ; a few sporadic cases of sleeping sickness occur but are not noticed ; finally the disease appears in epidemic form, the farm is deserted and the people scatter to surrounding villages. Such a history of events is frequently obtained, and ruins of deserted villages near tsetse-infested streams bear evidence of what has occurred. The peaceful state of the country under British control has led to a migration from towns to settlement upon farms and has probably increased the incidence of sleeping sickness very considerably. The actual yearly mortality from the disease is no doubt insignificant when compared with that of common diseases, such as pneumonia or small-pox, but sleeping sickness is of the greatest practical importance as a factor inhibiting the extension of farming into fertile areas.

A tabulation of a few of the sleeping sickness outbreaks of which notes are to hand shows how widely over the country the disease is spread. It shows also (Table VII) that the disease occurs in the presence of *G. palpalis* alone (Nassarawa Province), *G. tachinoides* alone (Zaria and Kano Provinces) and *palpalis* with *tachinoides*. Its occurrence in the presence of *tachinoides* alone is of great importance

in view of the wide distribution of this species throughout the Northern Provinces, more especially in the drier parts of the north and north-east, where farming along the course of streams is necessarily more widely practised.

TABLE VII.

*Showing Localities where Sleeping Sickness has been diagnosed, and the Prevalent Species of Tsetse-flies in such Localities.*

| Province. | Locality. | Diagnosis confirmed microscopically. | Species of tsetse present. *G. tachinoides* | *G. palpalis* | *G. morsitans* | Notes. |
|---|---|---|---|---|---|---|
| Zaria. | Kateri, between R. Dinia and R. Garara. | + | + | ++ | — | Sporadic. |
| ,, | Gimi, near R. Gulma. | + | + | — | — | Epidemic. |
| ,, | Kaduna. | + | + | + | — | Sporadic cases, 1918–1920. |
| Kano | Baserka, Dingaiya valley. | + | + | — | — | Sporadically epidemic; villages deserted. |
| ,, | Aulami and Hadubia, villages near Kiawa R., Sokwa District. | + | + | — | ± | Epidemic; sporadic cases seen in 1922. |
| ,, | Murgu and Pascola, villages near Tudun Wada. | 0 | + | — | — | Epidemic 1919: one clinically positive late case seen 1921. |
| Yola. | Bang, near Numan, 8 miles south of R. Benue. | + | ? | — | — | Epidemic. |
| Muri. | Jibu, Sansanni, near R. Benue. | + | ++ | + | ± | Epidemic. |
| Munshi | Katsina Ala. | + | + | + | — | Sporadic cases. |
| Kabba. | Lokoja. | + | ++ | + | ± | Sporadic cases. |
| Nassarawa. | Jemaa. | 0 | — | + | — | Epidemic. |
| ,, | Womba. | + | — | + | — | Epidemic. |

Several instances of sleeping sickness in purely *tachinoides* areas have come under our notice, and the localities have been visited during the past year. The following examples may be quoted.

1. Gimi, Zaria Province. A new settlement for sugar farming upon the border of a marshy valley close to its emergence into the River Gulma. In 1919 epidemic sleeping sickness occurred with many deaths, and the villagers mostly scattered, but when visited by one of us in 1920, 60 persons remained of whom 15 showed symptoms of the disease and the blood of three contained trypanosomes. Two other cases (trypanosomes in gland juice) were discovered in neighbouring villages where the disease had not been epidemic. Revisited by us in 1921 after the village had been moved half a mile from the valley and the ford on the River Gulma had been cleared of shade, no new cases were discovered. *G. tachinoides* was present upon the banks of the River Gulma and the flies extended up the marshy valley in the rainy season; no other species of tsetse was taken upon either visit. The villagers of Gimi had lived in intimate contact with fly and had suffered an epidemic of sleeping sickness,

whereas villages further up the valley, whose inhabitants had only occasional contact with fly, had suffered only sporadic cases. The relative position of these villages to the fly area is shown in the accompanying sketch map (*a*).

2. Aulami district, Katagum Division, Kano Province. Farming villages upon the edge of thorn forest, swampy in the rains, bordering the Kiawa River not far from its junction with the Katagum River. The villages of Aulami and Hadubia had been deserted when we visited the area in 1921, but villages on high sandy ground adjoining, but further from the river, remained, although sporadic cases of sleeping sickness occurred in them. Trypanosomes were found in the gland juice of two natives who had lived in the villages now deserted and in one inhabitant of a village upon the high ground. The banks of the Kiawa River are infested by *G. tachinoides*; the inhabitants of Aulami and Hadubia had lived in intimate contact with the fly until sleeping sickness occurred in epidemic form, whereas only sporadic cases had occurred in villages upon the higher ground away from the river, where water is obtained from wells and only occasional contact with fly is incurred. *G. tachinoides* is the prevalent fly, but *morsitans* is present in small numbers in the thorn forest; *palpalis* is not present. The relative positions of these villages to the fly area are shown in sketch map (*b*).

3. The Dingaiya Valley, Kano Province. A stream infested by *G. tachinoides* running parallel with and to the north of the main road from Kano to Nafada between Dingaiya and Baserka, near which place it falls into the Messau River. Deserted villages are scattered along this valley, notably the villages of Kundum and Kaserindum, and the history obtained is always that of farming new areas along the stream followed by epidemic disease within a year or two. No cases were seen upon our visit in 1921, but Dr. E. J. Porteous in 1914 found trypanosomes in the gland juice of one case at Baserka who had been infected at Kundum. *G. tachinoides* is the only species of tsetse in this district.

4. Villages upon the tsetse-infested tributaries of the River Kano, south of Tundun Wada, Kano Province; visited by us in 1921. Conditions were found to be similar to those described in (3) above, with desertion of farms; one clinically positive late case of sleeping sickness was found, but trypanosomes were not demonstrated. *G. tachinoides* was the only species of tsetse taken in this district.

5. Many other instances have come to our notice elsewhere in Kano and Bauchi Provinces, notably in the latter Province along the Waja River, a tributary of the River Gongola, where *tachinoides* and *morsitans* were taken in numbers but *palpalis* did not appear to occur.

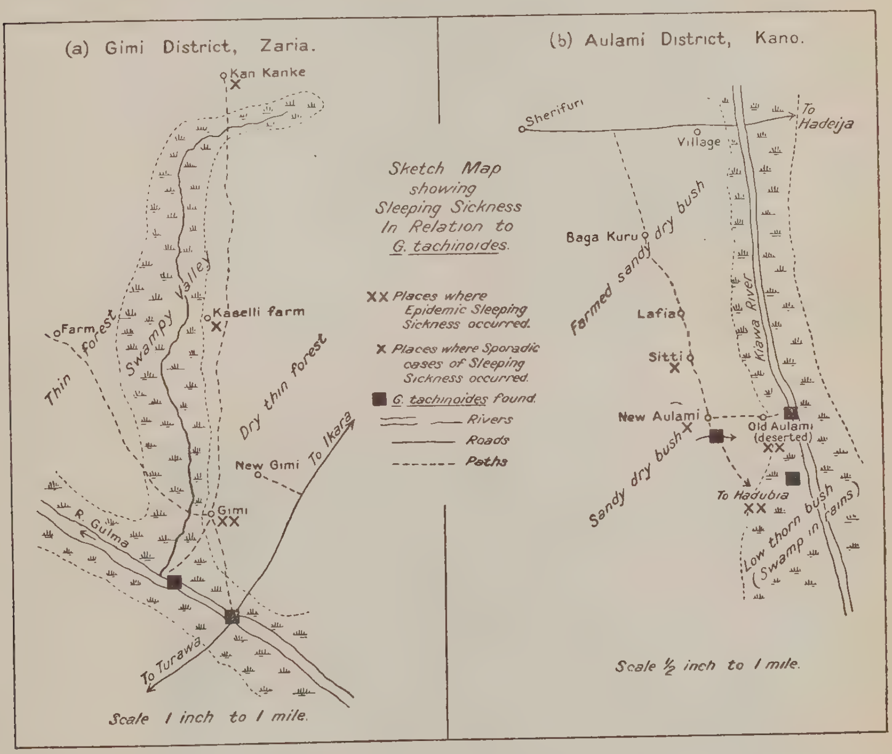
The incidence of epidemic sleeping sickness in association with intimate contact of man with *G. tachinoides*, and of sporadic cases where contact is less intimate, is shown in sketch map (*a*) and (*b*) of the Gimi and Aulami districts described above.

We have not come across any association in the native mind between tsetse and sleeping sickness, but instances of avoidance of tsetse streams or forest are common. The usual explanations given are (1) that the area is haunted by spirits, or (2) that the water is bad—we have camped near such an area where the natives fetched water from a distance rather than use that of a pool close to our camp. The dangerous nature of the water is ascribed variously to the presence of poisonous leaves (e.g. the leaves of the sasswood, *Erythrophloeum guineense*), or rather quaintly to the fanciful assumption that mosquitos void their urine therein.

It is clear that sleeping sickness can appear and become epidemic in localities where the only tsetse carrier present is *G. tachinoides*, and it is at least probable that this species is responsible for the disease in such areas as the mid Benue region, where *tachinoides* abounds and *palpalis* is scanty. As an example of this, Jibu, at the mouth of the Donga River, may be quoted. Here a large farm abuts on a piece of forest infested by *tachinoides*, which was found to be breeding within a few yards

of the farmed area giving exactly similar conditions of intimate contact between fly and man to those described above in Zaria and Kano Provinces. *G. palpalis* occurs further up this river but has rarely been taken near its mouth. Sleeping sickness is endemic.

Elsewhere we have produced evidence that *tachinoides* can flourish in localities where man is its most available and therefore most favoured host. Experimental proof that *tachinoides* is a carrier of human trypanosomiasis is not yet complete, and we were not fortunate enough to discover a single mature *T. brucei-gambiense* group infection among the 1,500 wild flies dissected, but transmission feeding experiments with wild *tachinoides* at Mashiwashi yielded an infection of a dog by a trypanosome of this group. Experiments in transmission of this group of trypanosomes by laboratory bred *tachinoides* are in progress.




## IX.—Summary and Conclusions.

1. There are three prevalent species of tsetse-fly in the Northern Provinces of Nigeria: *G. palpalis*, *G. tachinoides* and *G. morsitans*. *G. longipalpis* is common in the south-west and *G. fusca* has been recorded from Kabba. The three prevalent species only have been studied.

2. *G. palpalis* and *tachinoides* are limited in distribution by forest conditions, the former being dependent on a mainly evergreen type of forest and the latter finding one which is a mixture of evergreen and deciduous trees sufficient. Food on which

they can subsist is always present in these. Impenetrable forest is inhibitory to both species. *G. morsitans* is dependent on a certain amount of shade but is also restricted in range by food supply, this being mainly that part of the fauna known as "game."

3. *G. palpalis* and *tachinoides* both draw a considerable proportion of their food from non-mammalian (probably reptilian) sources, but the latter is less addicted to this diet, preferring mammalian blood, though not that of antelope in particular. Both can thrive where the wild fauna is reduced to its possible minimum, and *tachinoides* where man is almost the only host available.

4. The breeding haunts of *G. tachinoides* are described. Typically they are in patches of sand in open places in the forest or in dry stream-beds, protected from the sun's rays by high shade but usually not by low bushes—a distinction from *palpalis*. The rate of breeding is restrained in the wet season and this is correlated with a reduction in nutrition due to seasonal causes, probably high undergrowth. There is no striking disproportion in the sexes in collections of *tachinoides* caught by the net.

5. The trypanosome infections of the flies are compared, these being twice as numerous in *morsitans* as in *tachinoides*, and twice as numerous in the latter as they are in *palpalis*. In *tachinoides* the trypanosomes which develop in the proboscis, or invade the proboscis when the infection is mature, are much more numerous where game animals are present than when these are virtually absent. These are the main stock-infecting forms.

A member of each of the three groups of pathogenic trypanosomes has been recovered from *tachinoides*.

Data are insufficient to estimate the local importance of *palpalis* as a disease carrier of domestic stock, but compared with *tachinoides* it is of small importance, since its range is greatly restricted in the main cattle country, whereas *tachinoides* ranges widely in contact with cattle and is not avoided.

*G. morsitans* areas are definitely avoided by stock owners seeking grazing grounds and so the fly has not great opportunity of infecting domestic stock. Its importance lies in the fact that it prohibits expansion and renders the best grazing country untenable, but there is no reason to suppose that it is spreading.

6. *G. tachinoides* is shown to be the carrier of sleeping sickness in the north-eastern and eastern parts of the country. Epidemics of the disease are liable to occur when new farms are made in contact with its haunts. This curtails expansion of population and the farming of the land, which is the best remedy against tsetse-flies.

7. It is therefore clear that *G. tachinoides* is the most important tsetse-fly in the Northern Provinces, and we propose to concentrate our work on an attempt to discover means for its control. This will be carried out in the densely populated parts of South Kano Province, where the prospects of prophylaxis appear to be most promising. It is anticipated that the work will resolve itself into a study of clearing problems, since we have already shown that the fly may not be controlled, or even completely sterilised, by any practicable curtailment of its food supply.

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Fig. 1. A palpalis haunt. Heavy forest along torrent stream in open hilly country near Zungeru, Niger Province.

Fig. 2. Bekin River, Nassarawa Province. Evergreen shaded river banks infested by G. palpalis.

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Fig. 1. Forest backing farm land near Jibu, River Benue. G. tachinoides present and breeding in the forest.

Fig. 2. A mimosa-filled creek near River Benue close to Lau. G. tachinoides present but not numerous.

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Fig. 1. Heavy evergreen forest suitable for G. palpalis, Nassarawa Province.

Fig. 2. Pati Hill, Lokoja, showing rather open type of heavy forest. G. tachinoides, palpalis, and longipalpis present. "Fly-boys" catching tsetse under opened black umbrellas.

Fig. 1. Thorn and partly deciduous forest bordering the Katagum River near Sherifuri. G. tachinoides and morsitans present. Compare with Plate XVIII, a palpalis infested river.

Fig. 2. Thorn forest near Sherifuri, Kano Province. Taken shortly after the passage of a forest fire. G. morsitans present.

Fig. 1. A tachinoides breeding ground, in stream bed near Patta, Bauchi Province. Pupae obtained in sand in angle of buttresses of fig tree (the white tree trunk) and in pocket of sand shaded by the rock in the background.

Fig. 2. A tachinoides breeding ground in a dry stream bed with high shade at Mashiwashi, Sokoto Province. Pupae obtained along the whole course of the sandy stream bed shown.


MAP OF THE
NORTHERN PROVINCES OF NIGERIA
Showing the known distribution of GLOSSINA and SLEEPING SICKNESS
REFERENCE
Localities where Glossina palpalis was found.
" " " tachinoides " "
" " " morsitans " "
" " " longipalpis " "
" " " fusca " "
" " Sleeping sickness " "
Route followed by the present investigators
" " " Dr. J.J. Simpson
FRENCH WEST AFRICA
SOKOTO
KANO
BORNU
ZARIA
BAUCHI
KONTAGORA
NIGER
NASSARAWA
ILORIN
KABBA
MUNSHI
MURI
YOLA
SOUTHERN PROVINCES
DAHOMEY
KAMERUN
LAKE CHAD
Railways open shown thus
" proposed " "
Miles 30 20 10 0 50 100 150 200 Miles

# FOUR NEW AFRICAN MOSQUITOS.

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**Aëdes (Stegomyia) chaussieri,** sp. n.

♀. *Head* clothed almost entirely with broad flat scales, though there are a very few narrow curved ones and a few upright forked ones on the nape. Scales at the back of the head mostly light ochreous; a rather broad creamy mid-dorsal stripe, and a conspicuous silvery margin to the eyes; remaining scales on upper part of head forming two large but irregular patches of black; another small black patch low down among the creamy scales on each side. Clypeus bare, dark brown. Eyes well separated. Orbital bristles dark brown. Proboscis blackish, slender, slightly longer than the front femora. Palpi fully one-fourth as long as the proboscis, blackish, with the usual conspicuous silvery apical patch. Tori blackish, with a large patch of silvery-white scales. *Thorax* with the integument uniformly black. Mesonotum clothed mainly with rather large and coarse, dull brown, narrow, curved scales, those surrounding the ante-scutellar space golden-brown, but scarcely any broader than the others, and not forming definite lines; no mid-dorsal golden line; a small patch of broad flat silvery scales in the middle of the front margin, and a small patch of narrower scales in front of the root of each wing; a pair of large crescent-shaped patches of broadly crescent-shaped silvery-white scales in the anterior half. Scutellum with the median and lateral lobes completely clothed with silvery scales. Prothoracic lobes, pro-epimera, and a large part of the pleurae clothed with silvery-white scales. About five pro-epimeral bristles, and about five post-spiracular; no lower mesepimeral. *Abdomen* clothed mostly with purplish-black scales; the first tergite, and a basal band on each of tergites 2–7, creamy white; all tergites with large silvery basal lateral spots, and sternites with silvery basal bands. Eighth segment rather prominent; cerci very short. *Legs* rather slender. Front femora almost entirely black; mid fermora black except for a small white spot on the anterior side just beyond the middle, and a rather conspicuous silvery-white tip; hind femora all white on the basal fourth, the outer side silvery-white to a little beyond the middle and also rather broadly at the tip. Front and middle tibiae with a small white spot at the base beneath, hind tibiae entirely black. Front and middle tarsi black, with narrow white rings at the bases of the first two segments; hind tarsi with rather narrow white rings at the bases of the first three segments, fourth segment white except for the extreme tip, fifth all black. Front and middle claws toothed; hind simple. *Wings* normal, the scales ligulate and rather dense. Wing-length 4 mm.

Belgian Congo: Sandoa (*Dr. Chaussier*); co-types, 4 ♀♀, presented to the British Museum by Dr. M. Langeron. N.E. Rhodesia: near Lake Young, Feb. 1905 (*R. L. Harger*); 2 ♀♀ in the British Museum.

This species is dedicated, at Dr. Langeron's request, to Dr. Chaussier, who has collected a number of mosquitos in the Belgian Congo. It is most closely allied to *S. poweri*, Theo., differing chiefly in the larger and lighter brown mesonotal scales, in having the scales at the back of the head pale, in the absence of fine golden lines on the mesonotum and the larger size of the crescent-shaped spots, and in the entirely dark hind tibiae.

**Aëdes (Stegomyia) masseyi,** sp. n.

Closely allied to *A.* (*S.*) *poweri*, Theo., differing as follows:—Silvery margin to the eyes continuous, not interrupted by black spots. The white patch on the front margin of the mesonotum composed of quite narrow scales instead of very broad

flat ones. Crescent-shaped spots on mesonotum larger, almost semi-circular. Middle femora without post-median white spot, but with traces of a longitudinal yellowish line on the basal half anteriorly. Hind tibiae entirely black. Hind tarsi with a moderately broad white ring at the base of the first segment, and a very narrow one at the base of the second ; third segment entirely black.

Belgian Congo : Ruwe, 7–8.v.1907, in house (*Dr. A. Yale Massey*) ; type and one other ♀ in the British Museum. N.E. Rhodesia : near Lake Young, Feb. 1905 (*R. L. Harger*) ; 1 ♀ in the British Museum.

As in *A.* (*S.*) *poweri*, the mesonotal scales are mostly dark brown, fine and closely placed ; there is a median golden line stopping short at the ante-scutellar space, and a pair of short whitish to golden lines reaching from the scutellum almost to the semilunar patches ; the fourth hind tarsal segment is entirely white and the fifth entirely black.

**Aëdes (Aëdimorphus*) lamborni,** sp. n.

♂. *Head* with a large area of narrow dark scales on the vertex, narrow pale ones on each side of this, then a small area of flat black ones, finally flat creamy ones on the sides. Orbital bristles black, verticals golden-yellow. Proboscis slender, rather longer than the front femora. Palpi slightly shorter than the proboscis ; long segment with a narrow pale ring at the constriction, its tip and the penultimate segment slightly swollen ; last two segments conspicuously hairy, each with a narrow pale ring at the base, terminal nearly two-thirds as long as the penultimate. *Thorax* with the integument dark brown. Scales : pronotal, narrow and pale ; pro-epimeral, broadish, curved and pale below, narrow and black above ; mesonotal, rather coarse and narrow, irregularly mixed black and golden ; a few broad, flat and whitish just in front of the scutellum in the middle ; scutellar, all broad, flat and creamy-white ; pleural, broad, flat and creamy white, in three not very large patches, the largest on the mesepimeron. Bristles : pro-epimeral, 4, black, in a regular row ; post-spiracular, 4–5, pale ; sternopleural dark, in a continuous row ; lower mesepimeral, none ; dorso-central and scutellar, long and dark. *Abdomen* : tergites 2–6, black-scaled with regular basal white bands ; 7, with small lateral white spots only ; 8, all white. Sternites white-scaled with narrow black apical bands. Basal lobes of side-pieces of hypopygium with the usual tuft of bristles ; claspers terminal, forked in the middle, the outer branch quite smooth and bare, pointed longer and a little stouter than the inner branch, which ends in a moderately long and stout claw. *Legs* : femora all blackish to the base dorsally, knee-spots creamy, small but distinct ; hind femora white to the tips beneath. Tibiae blackish, white at the tips dorsally ; on the front and middle legs the white is about equal to the diameter of the tibia, on the hind legs three times as long. Front and mid tarsi with the first two segments narrowly white at the tips. Hind tarsi with the first segment blackish at the base, broadly white at the apex ; second and third broadly white at both base and apex ; fourth broadly white at the base, narrowly at the tip ; fifth all white. Front and mid claws each with one tooth, hind simple. *Wings* with the scales all dark, those on the forks ligulate ; upper fork-cell scarcely longer than its stem. Wing-length, 4 mm.

Nyasaland : Zomba, 1 ♂ reared from larva found 11.i.1922 in a pool of foul water in a cavity in the top of a well-shaded rock on the banks of the Mulungusi River (*Dr. W. A. Lamborn*) ; type presented to the British Museum by the Imperial Bureau of Entomology.

This species is very distinct from all others yet known from Africa ; in position it seems to be somewhat intermediate between the *A. marshalli* and the *A. tarsalis* group. Its nearest ally is apparently *A. lowisi*, Theo., of the Andaman Islands.

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* I have previously (following Dyar) used the name *Ecculex* for this subgenus, overlooking the fact that Theobald's *Aëdimorphus* was published a year previously.

**Culex (Culiciomyia) macfiei,** sp. n.

*Head* with the integument dark, clothed for the most part with narrow greyish-ochreous scales, and upright dark scales towards the nape ; round the eye-margins, but not quite reaching the mid-dorsal line, is a rim of very small, flat white scales. Palpi of ♂ equalling the proboscis in length, the outer half of the long segment with a row of eight outstanding transparent scales, which are broad near their base and end in a long point ; terminal segment twice as long as the penultimate. Palpi of ♀ rather slender, exceeding the clypeus by about one and a half times the length of this part. Proboscis and palpi uniformly dark in both sexes. Antennae dark, the bases of the flagellar segments of the ♂ white ; verticil hairs of intermediate flagellar segments of ♀ over three times as long as the segments, pubescence shorter than the segments. *Thorax* : integument of mesonotum dull dark grey ; pleurae rather light ochreous, with a green tinge, slightly dusted over with grey. Mesonotal scales rather dull brownish-grey, somewhat coarser than those of *C. nebulosus* ; prothoracic lobes, pro-epimera and scutellum scaled like the mesonotum. A few pale flat scales on the sternopleura ; one well-marked lower mesepimeral bristle. *Abdomen* blackish-scaled dorsally, tergites 2–7 each with a small but fairly well-marked basal lateral white spot. *Hypopygium* small and pale, weakly chitinised. Side-pieces rounded, not much longer than broad ; the lobe not well developed and not distinctly divided, bearing two fairly stout rods with slightly hooked tips, about six to eight more slender setae and some undifferentiated hairs ; a little apart from this group is a flattened blade representing the leaf, which is rather long and narrow with a rounded tip, and close to this is a very stout, bluntly pointed spine. Clasper bent in the middle almost at right angles, with a single recurved hook about the middle of the apical half, and a single fine hair near the tip. Tenth sternites short and broad, without basal projection, spines numerous, all pointed, slender, irregularly arranged. Lobes of mesosome rather gradually tapering, each with a strong tooth at the base on the inner side. *Legs* dark, the femora pale beneath, but without pale knee-spots, hind femora white all round on the basal half, and white externally almost to the tip ; tips of tibiae dark. *Wings* with the scales all dark, the outstanding ones on the forks almost linear. Upper fork-cell a little over twice as long as its stem, its base nearer the base of the wing than that of the lower. Cross-veins separated by fully the length of the posterior. Halteres with pale stem and dark knob. Wing-length, ♂ 2 mm. ; ♀ 3 mm.

Gold Coast : Ofako, reared from larvae in tree-hole, 24.v.1922 (*Drs. Ingram* and *Macfie*) ; type ♂, one other ♂ and 3 ♀♀, presented to the British Museum by the Imperial Bureau of Entomology.

This species, though obviously closely allied to the other African members of the group, differs from them in the basally situated pale markings of the abdominal tergites, and in many other details. The larvae preserved by the collectors are very distinct from those of *C. nebulosus*.

# TWO NEW SPECIES OF TABANIDAE FROM CUBA.

By E. Brunetti.

**Chrysops guiterasi,** sp. nov.

♂. *Head*: Eyes closely contiguous, leaving a small, well-raised, brownish-grey dusted ocellar tubercle at vertex with rather large, shining brown ocelli and a few short pale hairs. Large facets of eyes pale brownish-yellow, the small facets nearly black. Frontal triangle extremely small, yellowish-grey dusted. Antennae with first joint moderately long and thick, broadly cylindrical, tapering at base; second joint shorter and narrower than first; subcylindrical, both with short black, stiff hairs; third joint of normal shape, bare, a little longer than first and second together, with five annulations, the last four being black, basal annulation and first and second joints wholly orange. Whole underside of head shining honey-yellow, a medium-sized yellow-dusted space on each side of face contiguous to eye margin. Proboscis and palpi a little deeper coloured, former with labella black. Occiput ash-grey dusted, lower part yellowish with a little pale soft hair.

*Thorax*: Dorsum orange-brown, with two median, moderately broad, narrowly separated, paler dust stripes, very distinct anteriorly, fading a little hindwards but attaining hind margin. A broad brownish-yellow dust stripe on each side margin from anterior corners to base of wing, leaving the ultimate edge of dorsum on each side orange-brown. Sides of thorax mainly yellowish-white, smooth, with an orange-brown horizontal stripe along middle, the lower part also orange-brown. Pubescence of whole thorax very short, sparse, pale yellow. Scutellum moderately shining orange-brown, with a little paler dust.

*Abdomen* mainly orange-brown, hind margin of first segment rather narrowly in middle, second segment on about anterior half, broadening towards sides, and a well-defined triangular space in middle of hind margin, also hind margins narrowly of remaining segments, the colour widened in middle of each into a large but rather indistinct triangle, successively smaller on each succeeding segment, pale yellowish. Pubescence of abdomen very short, pale yellow, inconspicuous, sparse. Venter brownish-yellow, paler, almost whitish, basally, and darker brown at tip.

*Legs* brownish-orange, about apical half of hind tibiae slightly darker, as are tips of tarsi joints, intensified by numerous small black bristles on these parts. Some fine pale yellow hairs on coxae and underside of posterior femora.

*Wings* pale grey; anterior margin dark blackish-brown, extending as far hindwards as second longitudinal vein, continued to wing tip, the band of about uniform breadth, ending in second submarginal cell. The usual transverse dark band across middle of wing, its sides nearly parallel to one another and running to hind margin of wing, delimited proximally by inner side of discal cell and distally just beyond end of this cell. About basal half of first basal cell and rather less of second basal cell blackish brown, as are also base and inner side of fifth posterior cell. Halteres blackish brown.

♀. *Head*: Frons yellowish-grey pollinose; ocellar triangle much less elevated than in ♂, the ocelli black; a large, transverse, oblong, shining orange-brown callus, filling nearly all lower half of frons; yellowish-grey dust spots on sides of face smaller, more elongate, transverse, one end contiguous to eyes. Sides of thorax more yellowish than in ♂. Abdomen darker yellowish-brown than in ♂, with about middle part of second segment and more than basal half of each remaining segment still deeper brown. Hind margins of segments narrowly and inconspicuously yellowish; no trace of pale triangular spots except indistinctly on second segment. Nearly apical half of fore tibiae, fore tarsi wholly, knees of middle legs, middle tarsi except first joint, tips of hind femora obscurely and hind tarsi except first joint, dark brown.

Length, 7½ mm.

Cuba: Manzanillo, 31.vii.1922 (*Col. C. H. Ballou* and *S. C. Bruner*).

*Type* ♂ presented to the British Museum, type ♀ in the Deutsches Entomologisches Museum, Berlin. Described from a single ♂ and ♀ sent by Dr. Horn to the Imperial Bureau of Entomology.

**Silvius punctipennis,** sp. nov.

♀. *Head*: Frons with practically parallel sides, about one-fourteenth total width of head measured across middle of frons, brownish-grey dusted; vertex flush with upper side of eyes, ocellar tubercle and ocelli very inconspicuous. A shining black callus, longer than broad, just above frontal triangle, with a narrow, shining black line extending upwards more than half-way to vertex. Eyes dark brown. Frontal triangle brownish-yellow tomentose. Antennae obscurely orange-brown; third joint with first annulation darker, remainder of joint black. Underside of head ash-grey, with a little fine white pubescence on lower part of cheeks and round base of proboscis, extending over lower margins of the wholly ash-grey occiput. Proboscis black; palpi rather slender, pale livid yellow with very short black hairs. Extreme tip of epistome shining yellowish-brown, bare.

*Thorax* obscurely blackish-grey; humeral region indefinitely whitish-grey dusted, the colour extending hindwards as a pair of pale yellowish, parallel narrow stripes towards each side of dorsum, nearly or just attaining hind margin; ends of suture irregularly whitish-grey, also lower margins of hind corners of dorsum. Sides of thorax wholly ash-grey with fine white pubescence. Scutellum concolorous with dorsum, margins indistinctly pale. Pubescence of dorsum of thorax black, very short and inconspicuous, more obvious on humeral region and above wings. Scutellar pubescence mainly whitish, a little longer than that of thorax, rather sparse.

*Abdomen* dull blackish; first and second segments more or less ochraceous towards sides; hind margins of all segments narrowly yellowish-white, with a fringe of short whitish hairs; pubescence on rest of abdomen short, black. Venter blackish, hind margins of segments whitish; pubescence short, whitish, uniform.

*Legs*: Coxae ash-grey dusted, with fine white pubescence. Femora mainly black; base of middle pair nearly to middle, of hind pair narrowly and tips of all pairs just perceptibly, orange-brown. Tibiae mainly orange-brown, apical half of fore pair, tips narrowly of posterior pairs blackish; fore tarsi practically all black, posterior tarsi dull orange-brown with tips of joints black. Pubescence of legs black and almost microscopic except for a little soft whitish hair below posterior femora.

*Wings* pale grey, iridescent, the following parts dark brown: costal margin, dying away narrowly near wing-tip, filling costal and subcostal cells; definite small suffusions over base of third vein and anterior cross-vein; fork of third vein; outer side of discal cell, fork of fifth vein and over the posterior cross-vein; most of the longitudinal veins just perceptibly suffused with brown. Halteres blackish brown, stems pale.

Length, 7–7½ mm.

CUBA: Sierra Maestra, 900–3,000 ft., 10–20.vii.1922 (*Col. C. H. Ballou* and *S. C. Bruner*).

*Type* ♀ and another ♀ presented to the British Museum, and a third specimen in the Deutsches Entomologisches Museum, Berlin. As few species of *Silvius* bear conspicuous dark spots on the wings, this one should be recognised without difficulty.

# A NOTE ON A BEETLE WHICH PREYS ON MOSQUITO LARVAE.

By J. W. S. Macfie.

Last July (1922) a species of beetle, kindly identified by Dr. G. A. K. Marshall as the Tiger beetle, *Cicindela octoguttata*, F., a common Tropical African species, was observed to prey on mosquito larvae at Accra, in the Gold Coast. As this habit of the beetle does not appear to have been previously observed, and as it is perhaps remarkable that it should prey on such entirely aquatic insects as mosquito larvae, the following brief note may prove of interest.

The beetles are commonly seen in the Gold Coast at the muddy margins of pools and lagoons, and at the time the observations were made were very abundant on the mud flats left by the receding of the water a little above the head of the Accra lagoon, and especially at the margins of the little pools and puddles left in these mud flats and on the level ground near them. They range about over the mud apparently in search of prey, moving rapidly, and being very wary they become alarmed and fly away if incautiously approached. They also frequent the water's edge and are often seen in long rows lining the margins of shallow pools and puddles. It is here that they prey on mosquito larvae, for these pools and puddles are a favourite nursery for the larvae of *Anopheles costalis*, Loew. I have watched them for hours preying on these larvae. They stand actually just in the water, very alert, with their antennae slightly divergent and directed downwards and forwards. It is the movements of the larvae apparently which attract their attention, when with a swift swoop they seize their prey, usually about the middle, drag it from the water, and carry it a few inches away from the pool to devour it. Their aim is not unerring, but nevertheless shows a considerable degree of skill, and occasionally they plunge so deeply for their prey that the greater part of the head is submerged. They prey not only on Anopheline, but also upon Culicine larvae (e.g., *Culex fatigans*, Wied., *C. thalassius*, Theo., and *Stegomyia fasciata*, F.), seizing them usually by the posterior extremity, and are equally partial to pupae, which they grip by the cephalo-thorax.

Mosquito larvae are not their only victims. I have actually seen them capture and carry off a species of water-boatman, *Anisops* sp., and they are frequently seen in places where there are no mosquito larvae and appear to find there some sort of provender, the nature of which I have been unable to ascertain. Dr. Marshall, however, informs me that he has observed an allied species in Rhodesia frequenting the edges of muddy puddles and catching various small insects, especially Diptera, that run about on the mud. On one occasion I found the beetles completely surrounding the margin of a shallow puddle crowded with tadpoles. Although I watched them for an hour I never saw them actually secure any of the tadpoles, which perhaps were too large and powerful for them, but they did attack a few I removed from the pool and laid on the mud at one side, nipping them repeatedly and sometimes flying off with them and devouring them at leisure. This observation suggests that perhaps they had been accustomed to prey on them at an earlier stage of their development.

# AN INTERESTING PRINCIPLE IN ECONOMIC ENTOMOLOGY AND SOME USEFUL APPLICATIONS.

By K. Kunhikannan, M.A., Ph.D., F.E.S.

In the course of my investigation of the serious pest of palms, *Oryctes rhinoceros*, it was observed that a great proportion of the larvae work their way several inches below the floor of the manure pit in which they thrive, for pupation ; and it occurred to the writer that attempts should be made to prevent the return journey by the insects as adults. Now the larvae and adults are of about equal girth, but as the former are soft-bodied they can squeeze themselves through holes which are impassable for the rigid-bodied adult. A sheet of expanded metal with meshes 12 by 24 mm. will let the larvae through but not the adults, and therefore should prevent the escape of beetles from manure pits in which the floor has been carefully covered with this metal. How far the idea will be of practical application in the control of the pest under the varying conditions in which manure is stored remains to be seen, but this preliminary note is written to draw attention not to any remedy but to the principle itself, which is important and has a wider application than to the insect from the study of which it was first derived. It has been found, for example, that it operates in the case of flies also, the holes through which the maggots may be able to pass being impassable for the adults. In the case of the house-fly a perforated zinc sheet will let the maggots through, but not the adults, and a trap is under trial in which the flies are attracted to suitable material and the maggots resulting from oviposition have to pass for pupation through a perforated zinc sheet into a chamber from which the flies cannot escape. The success of this trap as well as of the lines of attack now opened up against *Oryctes rhinoceros* remains to be seen, but the principle is, I believe, of sufficient importance for early attention to be drawn to it in the pages of this journal.

# SOME NEW CULICINE MOSQUITOS FOUND IN INDIA, AND A NOTE ON *FINLAYA ASSAMENSIS* (THEO.).

By P. J. Barraud, F.E.S., F.Z.S.

(*In charge of an Enquiry upon Indian Culicidae, under the Indian Research Fund Association.*)

In this paper short descriptions of several new species of the genus *Finlaya*, Theo., are given, together with a note on *Finlaya assamensis* (Theo.). These will be dealt with more fully in another paper which is now in preparation, and which will include synoptic tables, photographs, and drawings of the male hypopygia, as far as possible, of all the species of this genus found in India up to the present; this paper will be published in the Indian Journal of Medical Research as soon as possible. Through the kindness of Dr. N. Annandale I have been able to examine a number of type specimens in the Indian Museum collection, and to obtain the loan of a few, of which photographs have been prepared.

**Finlaya shortti,** sp. n.

This does not appear to be very closely related to any other Oriental species that I have seen, with the exception of *F. elsiae*, sp. n., described below.

Head mainly dark, with a median triangular area of whitish narrow scales on the vertex reaching to the eye-margins. Proboscis, in the male, with a narrow pale ring beyond the middle, in the female a wider pale area in the same position beneath and at the sides, not forming a complete ring. Palpi in the male about three-quarters the length of the proboscis, the last two segments turning downwards and bearing conspicuous hair tufts. Female palpi quite short, dark, except at the extreme tip, where there are a few whitish scales. Mesonotum in both sexes dark blackish brown marked with lines of whitish yellow scales as follows :—A double median line dividing posteriorly either side of the ante-scutellar space; a pair of sub-lateral lines joining the fork of the median before the scutellum; a pair of curved lateral lines over the wing-roots. Scutellum with whitish and rather narrow lanceolate scales on all the lobes. Pro-epimera dark in the middle, with whitish lanceolate scales along the upper and lower borders; prothoracic lobes with a row of similar scales. Legs: front and mid femora with anterior surface black speckled with pale scales tending to form lines, dorsal edge dark from base to knee-joint; front pair posteriorly lined with whitish; mid pair entirely pale for more than the basal half, scattered pale scaling to the tip. Front and mid tibiae with dorsal edge dark except for extreme base and tip, a pale line anteriorly along the basal quarter; posteriorly front pair lined with white, mid pair pale only at the base. Front and mid tarsi dark, with small white markings at the base of the first, second and third segments, which do not form very definite rings except on the first segment; a few pale scales dorsally at the base of the fourth segment. Hind legs with anterior surface of femora dark, with an irregular line of pale scaling along the middle half and a sub-apical mark of similar colour; dorsal edge entirely dark except just before the knee-joint, where the anterior sub-apical pale mark is produced dorsally; posterior surface white for rather more than the basal half, scattered pale scaling to the apex (the latter is absent in some of the paratypes); tibiae dark with basal pale ring, narrow dorsally; tarsi dark with narrow but complete white rings at the bases of the first four segments, all about the same width. Abdomen dorsally blackish brown with narrow basal white bands, and small lateral silvery spots to tergites. Sternites with basal white

bands, narrow in the middle and produced diagonally at the sides. (In some of the paratypes the basal bands do not show on the dorsum, probably owing to shrinkage of the abdomen.)

*Type* male and female, one other male and three other females, Shillong, Assam, June 1922; larvae from rock-pools (*Barraud*).

**Finlaya elsiae,** sp. n.

This resembles *F. shortti*, sp. n., described above, in the markings of the mesonotum and in some other details, but differs in the scaling of the legs and proboscis as follows: Proboscis in both sexes entirely white for the whole length beneath, except for a basal black ring and a small dark interruption rather more than three-quarters of the length from the base; in the female, dark above but for the sides, which are narrowly pale from near the base for three-quarters of the length; in the male only very narrowly pale at the sides beyond the middle. Legs: anterior aspect of all the femora with a whitish line running the whole length (on the fore pair this line is along the ventral edge towards the base). Fore and mid tibiae with a similar line anteriorly, hind tibiae only white anteriorly and ventrally for the basal one-third, dorsal edge dark except for a narrow basal white ring. Fore and mid tarsi dark, with dorsal white markings over the joints between the tibia and first tarsal, first and second, second and third, a few pale scales in some specimens on either side of the joint between the third and fourth; hind tarsi with similar markings, rather broader than on the other legs, except that the apex of the tibia has only a few pale scales.

*Type* male and female, and a long series of other specimens, from Shillong, Assam; larvae in rock-pools, June 1922 (*Barraud*).

**Finlaya cacharana,** sp. n.

Differs from *Finlaya gubernatoris* (Giles) in both sexes in having moderately developed projecting tufts of scales on the venter of the abdomen; the tarsi of the fore legs entirely dark; pro-epimera bare except for a small collection of flat white scales on the posterior border, and in the male in having the mesonotum almost completely covered with white scales. Differs from *Finlaya assamensis* (Theo.) (*vide* notes below under this species) in having the scutellum pale-scaled in both sexes, and in the scaling of the pro-epimera, which in *F. assamensis* bear a fairly large patch of flat white scales in the middle. Distinguished from *F. lophoventralis* (Theo.) in having the scutellum much less densely clothed with pale scales, the inter-lobular spaces being bare, and in having the ventral surface of the front tibiae entirely pale except at the extreme tip. Differs from *F. cogilli*, Edw., as follows:—Head with a narrow median white line; scutellum with flat creamy scales on all the lobes; abdomen with moderately developed ventral tufts of outstanding scales. I have not seen any specimens, or a description of *F. melanoptera*, Giles, but understand that the ventral abdominal tufts in that species are extremely long, which is not the case in the species described above.

*Type* male and female from Haflong, Assam, July 1922; larvae from tree-holes; nine other specimens from the same place, and ten from Nongpoh, Assam, July 1922 (*Barraud*).

**Finlaya greigi,** sp. n.

Differs from *Finlaya chrysolineata* (*trilineata*) (Theo.) and allied species in having the proboscis entirely dark in both sexes. The female differs from Theobald's description of the female of *Finlaya japonica*, Theo. (*Culex japonicus*, Mon. Cul. i, p. 385) in having much narrower white rings on the hind tarsi, in the absence of white knee-spots on the fore and mid legs, and in having white scaling at the tips of the palpi. Distinguished from *F. jugraensis* (Leic.), and *F. koreicus*, Edw., in having

white-tipped palpi in the female, and in the leg markings of both sexes as follows :—Front femur dark anteriorly without a creamy patch, and without a pale area at the apex ; mid tarsi with two very narrow basal pale rings, a few white scales at the base of the third segment, none at the base of the fourth ; hind tarsi with three white rings, that on the third segment being the widest, none on the fourth or fifth.

The mesonotum is marked with a well-defined median golden line, which posteriorly divides into two thin branches on either side of the ante-scutellar space, and two sub-lateral straight lines running from the front, back to the lateral lobes of the scutellum. These lateral lines are less defined than the median and are interrupted by a small dark space at the suture. In the markings of the mesonotum this species appears to be distinct from *F. saxicola*, Edw. (*Hulecoeteomyia fluviatilis*, Leic.), which is described as having seven golden lines, though it appears to be closely related to that species in other respects.

*Type* male and female, four other males and one female, Haflong, Assam, larvae from rock-pools ; one female from Kurseong, Darjiling Hills, larva from tree-hole ; all August and September 1922 (*Barraud*).

**Finlaya khasiana,** sp. n.

This species is evidently closely related to *Aëdes formosensis*, Yam., from Japan (of which, so far as I am aware, only the female has been described) and *F. chrysolineata* (*trilineata*) (Theo.). The female differs from the former in having pale scaling on the lower surface of the proboscis for the basal three-quarters, and in the marking of the hind femora, which, except for a narrow basal black ring, are pale on the basal half of the anterior surface. It differs from the female *F. chrysolineata* in having the proboscis entirely dark on the upper surface (or with a few pale scales showing at the sides in the middle), in the scaling of the pro-epimera, which have narrow curved yellow scales on the upper part, and in the marking of the hind femora, which have a narrow, instead of a broad, basal black ring. The mid femora have a few white scales dorsally at the knee-joint (in some specimens these appear to be wanting). The male is distinguished from that sex of *F. chrysolineata* as follows :—Pro-epimera with narrow curved yellow scales on the upper part, proboscis with a narrow pale ring beyond the middle, no other pale scaling beneath ; basal black ring on hind femora and third white ring on hind tarsi, narrower.

*Type* male and female, and five other specimens, from Shillong, Khasi Hills, Assam, June 1922, larvae from bamboo stumps ; one female from Sureil, Darjiling Hills, October 1922, caught in house (*Barraud*).

**Finlaya harveyi,** sp. n.

This rather closely resembles *F. khasiana*, sp. n., *F. chrysolineata*, and *Aëdes formosensis*, but differs from all in having the fore and mid femora entirely dark anteriorly, without any pale scaling or lines ; from *F. chrysolineata* and *F. khasiana* (described above), in having the proboscis pale beneath only on the middle half ; from the former in having the proboscis entirely dark on the upper surface, yellow narrow scales on the upper part of the pro-epimera, and in the white area on the anterior surface of the hind femora being nearer to the base. In the last mentioned character *F. harveyi* also differs from the description of *Aëdes formosensis*. The male differs from *F. chrysolineata* and *F. khasiana* in the characters of the front and mid femora mentioned above, and from *F. chrysolineata* in having a narrow pale ring on the proboscis, without any other pale scaling beneath.

*Type* male and female, and a further long series from Kurseong, and other places in the Darjiling Hills, September and October 1922 ; larvae chiefly from tree-holes (*Barraud*).

**Finlaya assamensis** (Theo.).

*Stegomyia assamensis*, Theobald, Rec. Ind. Mus. ii, pt. 3, Oct. 1908, p. 290.

I have examined Theobald's type female of this species, and although it is now in poor condition, I find that it possesses several characters which show that it is distinct from *Finlaya gubernatoris* (Giles), under which it was sunk by Edwards. I have recently collected about 100 fresh specimens of this species from various places in Assam and Eastern Bengal, and have compared many of the females with the type. The chief points of difference were mentioned in Theobald's original description, and are as follows :—Tarsi of fore legs entirely dark (in *F. gubernatoris* the first tarsal segment is usually whitish on the ventral surface, and in the female there is white scaling over the joint between the first and second segments ; these characters are much less marked in the male). Scutellum, in the female, clothed with flat blackish-brown scales on the mid lobe and sparse lanceolate scales of the same colour on the lateral ; at the base of the mid lobe there may appear to be a few lighter scales, possibly due to the angle of light. In the male the scutellar scales are whitish (as in several other species in this group, in which the female has dark scales in this position, viz., *F. khazani*, Edw., and others). Abdomen with small but evident tufts of outstanding scales on the venter, and rather long scales in the mid dorsal line which tend to stand away from the terminal tergites. The following further points may be mentioned :—Mesonotum, in the male, entirely covered with whitish scales, except for a few very small dark areas between the level of the wing-roots and the scutellum ; in the female, with a rather small anterior white patch, usually smaller than in *F. gubernatoris*. Both species show variation in the width of the white rings on the mid legs, but in *F. assamensis* these are generally narrower. The Central Malaria Bureau, Kasauli, collection contains specimens from :—Dibrugarh, Nongpoh, and Haflong, Assam ; Rangamati and Sukna, Bengal ; all July, August and September 1922 (*Barraud*).

The types and other specimens of all the new species described in this paper are at present in the collection of the Central Malaria Bureau, Central Research Institute, Kasauli, Punjab, India, but it is intended to forward these to the British Museum (Natural History), London, at the termination of my enquiry. Where possible, co-types and paratypes will be retained in the Kasauli collection, and others deposited in the Indian Museum collection, Calcutta.

# THE EARLY STAGES OF WEST AFRICAN MOSQUITOS.—VI.

By J. W. S. Macfie and A. Ingram,
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In this paper are described the early stages of a few more West African mosquitos. All the specimens were collected in the Gold Coast, and most of them at Accra or in the neighbourhood of that town. In drawing up descriptions of larvae we have followed the usual plan, but in the case of the setae on the head have given, when necessary, the terms employed by W. D Lang in his admirable handbook of British Mosquitos. In drawing up descriptions of pupae we have used the terms (and lettering) suggested by one of us in his account of the chaetotaxy of the pupa of *Stegomyia fasciata* (*Aëdes argenteus*).* We have once more to express our indebtedness to Dr. G. A. K. Marshall, of the Imperial Bureau of Entomology, and to Mr. F. W. Edwards, of the British Museum, for help and advice and for the identification of species, and to Mr. A. J. Engel Terzi for his skilful execution of the figures.

**Anopheles nili,** Theo.

Larva.—The larva of this mosquito has not yet been identified.

Pupa.—The pupa is rather small, length about 4 mm. when extended, and not very highly chitinised. Two specimens were examined.

*Cephalothorax.* The respiratory trumpets resemble those of *A. rufipes.*

*Abdomen* (fig. 1). The paddles, which are about 0·65 mm. long, are rather narrow, especially at their bases, the ratio of length to greatest breadth being about 1·9 to 1. The midrib is very feebly developed, almost absent indeed, and the external buttress is ill-defined but appears to extend beyond the middle of the paddles. At the distal end are the usual two hairs, the proximal one small, straight, single or double, and the terminal one large, stout, shaped like a boot-hook. The fringe is rather long and very delicate, and extends round almost the whole paddle except only for a short distance on each side at the base.

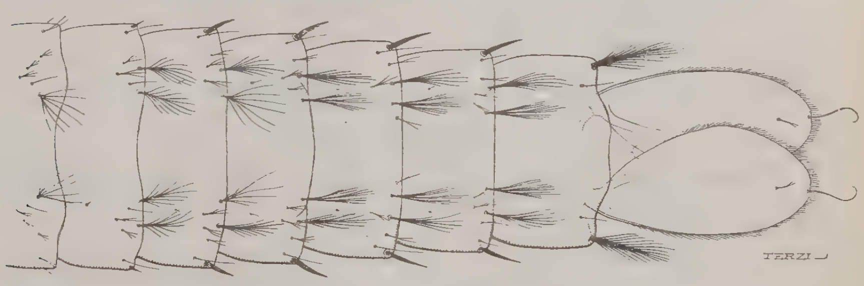


Fig. 1. *Anopheles nili*, Theo., abdomen of pupa, dorsal view.

The lateral setae (A) at the posterior angles of the abdominal segments are similar to those of *A. funestus*, and are very highly chitinised on the fourth to the eight segments. On segment viii they are long stout setae, about one quarter the length of the paddles, which give off numerous branches on each side ; on segments v, vi, and vii they are moderately long, strong, slightly curved setae, with sharp

* Bull. Ent. Res. x, p. 164.

points; on segment iv they are smaller but still of considerable size, strong and sharply pointed; but on segments ii and iii they are minute, sharply pointed setae, and rather feebly chitinised. The sublateral (B) and submedian (C) setae on the dorsal aspect of the abdomen are unusually well developed, and on segments iii to vii they are large tufts. The sublateral setae resemble the lateral setae on segment viii, that is, they have a central stem which gives off numerous branches on each side; the submedian setae are more like ordinary branched setae. The dendritic tufts on segment i are large and composed of long, fine hairs. The other setae of the pupa do not appear to call for special mention.

*Diagnosis.*—The pupa of *A. nili* somewhat resembles that of *A. funestus*, from which, however, it may be distinguished by having the submedian setae on segments v to vii developed as tufts instead of being long single or double hairs, as well as by other characters.

*Habitat.*—Oblogo, 7.ii.1921, larvae collected among plants of the water lettuce (*Pistia stratiotes*) in the river Densu.

**Megarhinus (Toxorhynchites) brevipalpis,** Theo.

A figure showing the paddles and the last three abdominal segments of the pupa of this mosquito has been published, together with a few words of explanation, by Bacot (Yellow Fever Commission, West Africa, Reports, iii, p. 145); and a larva, presumed to be that of *M. brevipalpis*, has been briefly described by Edwards (Bull. Ent. Res. iii, p. 375). Neither of these authors, however, has given sufficient details to distinguish the species, and indeed it seems not unlikely that the characters mentioned by them are mainly generic. As we have in our possession specimens of both larvae and pupae of *M. brevipalpis*, we have taken the opportunity of examining them in detail.

LARVA.—The larva when fully grown is very large, about 14 mm. long, and dark grey or reddish-brown coloured, corresponding in tint to that of the debris at the bottom of the water in which it is found. In the laboratory, when under observation, we have fed it on larvae of *Aëdes argenteus* (*Stegomyia fasciata*). When at the surface of the water the attitude of the larva is less horizontal than that of *Lutzia tigripes*. If disturbed the larva at once seeks the bottom of the jar in which it is confined and is able to remain there for several minutes at least without coming to the surface to breathe.

*Head* (fig. 2, *a*) relatively small, highly chitinised. Clypeus deeply notched in the middle. Antenna (fig. 2, *b*) short, cylindrical, smooth, with a very small tuft and two hairs on its inner aspect near the distal extremity. Mouth-brushes (fig. 2, *c*) small, composed of about ten (eight or nine) strong curved elements which are highly chitinised and not pectinated but armed at their tips with two small teeth. Mandibles very powerful, armed with two large and three or four smaller teeth (fig. 2, *d*). Mental plate very highly chitinised and black, flat, with a large, notched, and not prominent central tooth, and with five to seven broad teeth on each side which are irregular in size (fig. 2, *e*). The setae on the head are small and inconspicuous; the most prominent are branched hairs, one arising actually in the eye spot, one above it, and two immediately in front of it; a short row of four setae, a small tuft internally and three single hairs externally, on each side of the dorsum laterally and almost on a level with the bases of the antennae; and three single hairs on each side of the clypeus. Ventrally there is on each side a small tuft a little posterior to the root of the mandible and one or two other small hairs.

*Thorax.* Median setae rudimentary, lateral short and stout. The plumose, or more correctly serrated, hairs are short and thick with relatively stout barbs; some of them are branched. All the setae, except the most minute ones, arise from chitinous plates.

*Abdomen.* There are serrated hairs arising from chitinous plates on every segment. Some of these hairs are relatively stout, slightly curved, and barbed only on their convex side (fig. 2, *f*). On segment viii there is a single large chitinous plate on each side, from the posterior margin of which arise two stout, curved, serrated setae. There is no comb. The siphonal and subsiphonal setae appear to be absent; the anal seta is a small single hair. The siphon is short, about twice as long as the diameter of its basal ring, and highly chitinised. There is no pecten. Near the base of the siphon, on each side, is a large tuft of three to five plumose hairs. The anal segment is slightly shorter than the siphon, completely chitinised; its posterior

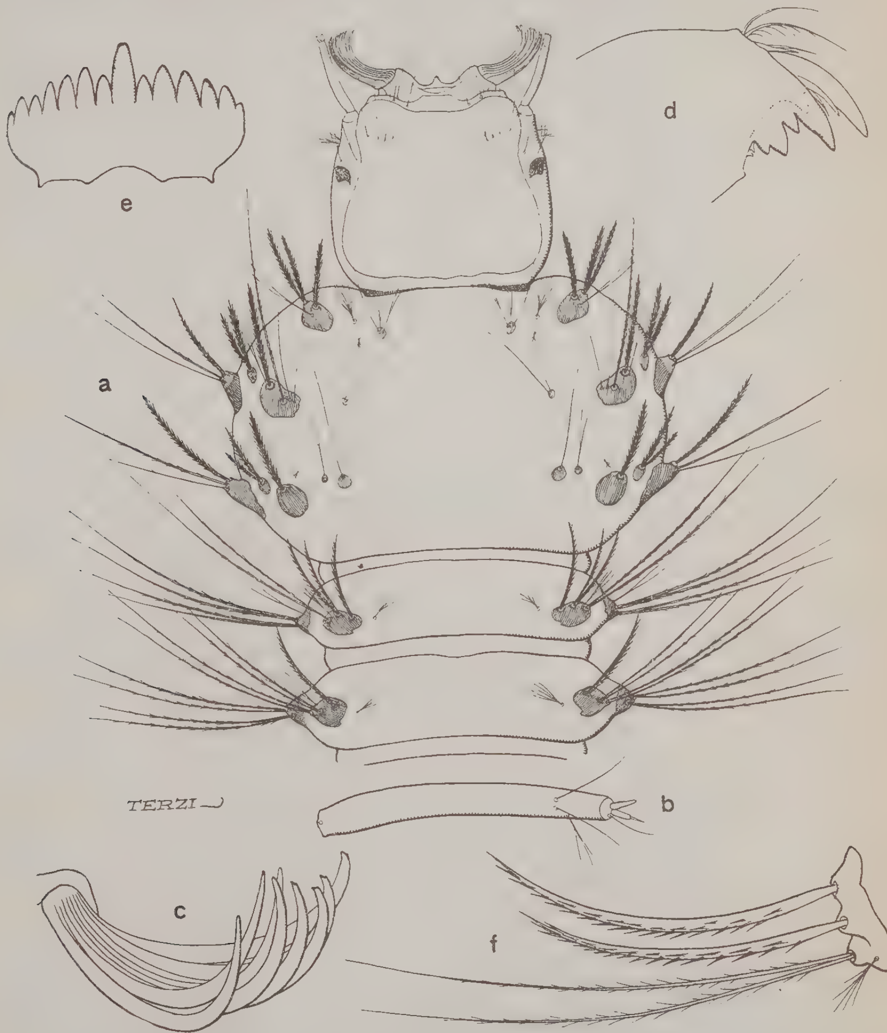


Fig. 2. Larva of *Megarhinus* (*Toxorhynchites*) *brevipalpis*, Theo.: *a*, anterior portion of body; *b*, antenna; *c*, mouth-brush; *d*, mandible; *e*, mental plate; *f*, plumose hairs of abdomen

border is fringed with long and short spines, and bears in the middle of each lateral margin a single stout serrated seta. The beard is well developed, composed of about ten pairs of branching hairs. The dorsal hairs on the posterior edge of the anal segment are long, four to six above and three or four below on each side. The anal papillae are very short and rounded, the dorsal pair being slightly the larger.

Pupa.—The pupa is very large, measuring about 14 mm. when extended, highly chitinised, and dark-coloured. The duration of the pupal stage is about five days.

*Cephalothorax.* The respiratory trumpets (fig. 3, *b*) are about 1 mm. to 1·2 mm. long; the ratio of the length of the closed portion (meatus) to the total length of the trumpet is about 1 to 1·3. The trumpet is narrow and slightly constricted at its base; it usually expands continuously towards its orifice, which is not very wide, but sometimes the distal end is slightly constricted and the lower third somewhat dilated. The arrangement of the cephalothoracic setae appears to be similar to that in *Aëdes argenteus* (Bull. Ent. Res. x, p. 162). There is one very long stout seta on the cephalothorax, which appears to be the superior post-ocular seta; the median and inferior setae of this group appear to be situated close together and are delicate, relatively short, single or double. Anterothoracic setae: lower anterior moderately long, divided into two or three branches; upper anterior delicate, rather longer, single; lower posterior small, single; upper posterior rather long, single. Dorsal seta delicate, rather long, single or double. Supra-alar seta delicate, moderately long, single. Postero-thoracic setae: internal, median, and external moderately well developed and divided into two or three branches.


Fig. 3. Pupa of *Megarhinus brevipalpis*, Theo.: *a*, dorsal view of abdomen; *b*, *b′*, respiratory trumpets.

*Abdomen.* The paddles (fig. 3, *a*) are large; the greatest length being a little over, and the greatest breadth a little under 2 mm., the ratio being 1·1 to 1. The midrib is well developed and divides the paddle into two unequal parts, the external portion being larger and longer than the internal. There are no setae at the distal end of the midrib. The external buttress is moderately well developed. The paddle bears a short fringe which, however, extends forwards on the external border only a short distance (about one-third of the external border). The surface of the paddles

is slightly granular or shagreened. The terminal processes at the posterior end of the abdomen bear rather stout single or double setae, or a small tuft of three to five hairs. The dorsal abdominal setae are arranged as shown in the figure (fig. 3, *a*) and therefore mention need be made of only the more important elements. The lateral setae (A) are extremely long (nearly 2 mm.) and strong on segments i to vii; they are single and pubescent or slightly subplumose. The sublateral setae (B) are present on segments ii to vii, are highly developed, very long, and similar to the setae of the lateral row. The submedian setae (C) appear to be present only on segments ii to v and are situated unusually far externally, close to the sublateral setae; they are similar to the lateral setae on segments iii to v, and on segment ii are modified into strong tufts and displaced somewhat inwards. The dendritic tuft on segment i is well developed, dark-coloured, and highly branched. The ventral abdominal setae are all small or relatively small and do not require special description. The abdominal stigmata are conspicuous.

*Habitat.*—Sekondi, 19.vi.1920 (*E. E. Grey*); Nsawam, a station about twenty-five miles north of Accra and on the fringe of the thick forest zone, 24.vi.1920; found in a rot-hole in the stump of a large silk-cotton tree (*Eriodendron anfractuosum*).

**Uranotaenia balfouri,** Theo.

Larva.—The larva of this species was described by Wesché (Bull. Ent. Res. i, p. 50). Having recently had the opportunity of examining several specimens of this larva at higher magnifications than those employed by Wesché, we should like to supplement his description as follows:—The larva when fully grown is about 3 mm. in length, the *head* is elongated, length about 0·6 mm., breadth about 0·5 mm.; the antennae, sparsely clothed with spicules, are very dark brown and short, length about 0·14 mm., bearing in place of a hair-tuft a single small hair a little before the middle. The pre-antennal tuft of Lang is a very small tuft of about three hairs; the outer post-antennal a tuft of three, four or more longish hairs, and the inner and middle post-antennals are stout and spine-like, similar to those of *U. alboabdominalis*. The mental plate is small, situated unusually far anteriorly, with a pointed central tooth and five or six smaller teeth on each side of it.

*Thorax* relatively broad, length about 0·7 mm., greatest breadth about 0·9 mm. The dorso-lateral setae composed of long, subplumose hairs arising from small chitinised plates, which bear also—especially those on the posterior third—small hook-like spines. On each side of the dorsum, in a sublateral position, is an anterior and a posterior tuft, the latter being the larger and composed of about a dozen hairs.

*Abdomen* bearing long lateral setae only on the first two segments. Eighth segment with two large lateral chitinous plates practically enveloping the whole segment, and a second pair of smaller chitinous plates posteriorly between the bases of the siphon and the anal segment. Comb set at the posterior margin of the large lateral chitinous plate, composed of five to eight large, pointed spines with fringed bases, which are graded, the longest being the third from the ventral end of the row. Wesché figures the comb but shows the longest spine at one end of the row. The siphonal, subsiphonal and anal tufts are well developed and composed of about six, six, and twelve hairs respectively, those of the subsiphonal tuft being subplumose and the others simple. The tufts situated about the middle of the siphon are composed of about twelve hairs. The pecten extends to slightly beyond the middle of the siphon, and is formed of about nine to twelve delicate, fringed scales somewhat similar to those of *U. alboabdominalis*. Anal segment completely chitinised, almost twice as long as broad, the posterior margin fringed with small spines and bearing on each side a tuft of four to six hairs. Beard poorly developed. Dorsal setae two to four above and two below on each side in the specimens examined. Anal papillae small, subequal, tapering slightly and ending in blunt points.

PUPA.—The pupa is small, length about 2·8 mm. when extended, not very highly chitinised but partly infuscated. The following description is based on the examination of two (male and female) pelts.

*Cephalothorax* infuscated anteriorly and posteriorly. Respiratory trumpets (fig. 4, *a*) somewhat infuscated at base and apex, short, length about 0·3 mm., straight, with moderately wide openings; ratio of length of meatus to total length of trumpet about 1 to 1·4. Cephalothoracic setae well developed and arranged as usual; dorsal setae tufts of about six hairs.

*Abdomen* (fig. 4) slightly infuscated, especially the sixth and seventh segments. Paddles of the shape characteristic of the genus; length about 0·43 mm., greatest breadth about 0·26 mm., ratio 1·6 to 1. The midrib and external buttress are well developed, and the distal half of the paddle is fringed with small denticles, which are largest and strongest on the outer border. The single seta at the distal end of the midrib is very small.

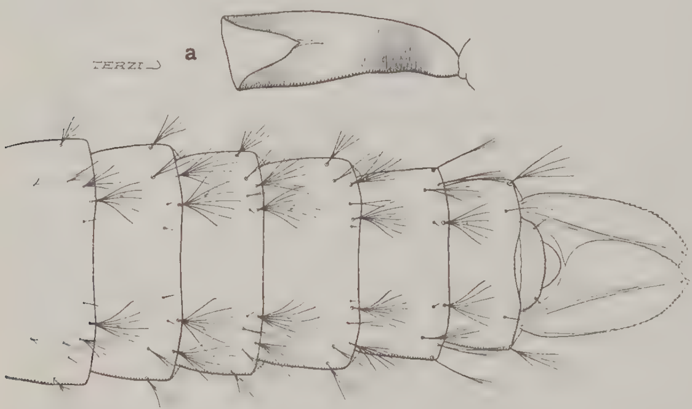


Fig. 4. *Uranotaenia balfouri*, Theo., dorsal view of abdomen of pupa: *a*, respiratory trumpet.

The dorsal abdominal setae are moderately well developed. The lateral setae (A) on segment viii are small, inconspicuous tufts composed of four very delicate hairs; on segment vii a rather long, delicate hair sub-divided at its end; and on segments iii to vi tufts of usually four hairs, which are long and delicate. The sublateral setae (B) on segments iv to vii are tufts of about six to ten long, delicate hairs (the more anterior segments bearing the larger tufts), which reach across to near the posterior margin of the following segment. The submedian setae (C) on segments iii to vii are long tufts of delicate hairs similar to the sublateral setae. The dendritic tufts on segment ii are moderately large; those on segment i are well developed and composed of about a dozen primary branches which are subplumose but not greatly branched.

*Habitat.*—Accra, and Ofako, a village about nine miles north of Accra on the road to Nsawam, v.1922. At both places the larvae were found in pools covered by the water-weed, *Pistia stratiotes*. The larvae in appearance, in habits, and in the position they assumed at the surface of the water, resembled young larvae of *Mimomyia splendens*, but could be distinguished with the aid of a hand lens by the smaller size of the head.

**Uranotaenia inornata,** Theo.

LARVA.—The larva is small, length when fully grown about 3·5 mm., and has a very dark-coloured head. The following description is based on an examination of two larvae.

*Head* (fig. 5) very highly chitinised and almost black; in the fully grown larva the length and the greatest breadth are about equal (0·7 mm.). Antennae very dark, short (0·6 mm.), almost cylindrical, bearing a single small hair in place of a tuft, and furnished at the distal end with the usual setae and sensory processes. Anterior

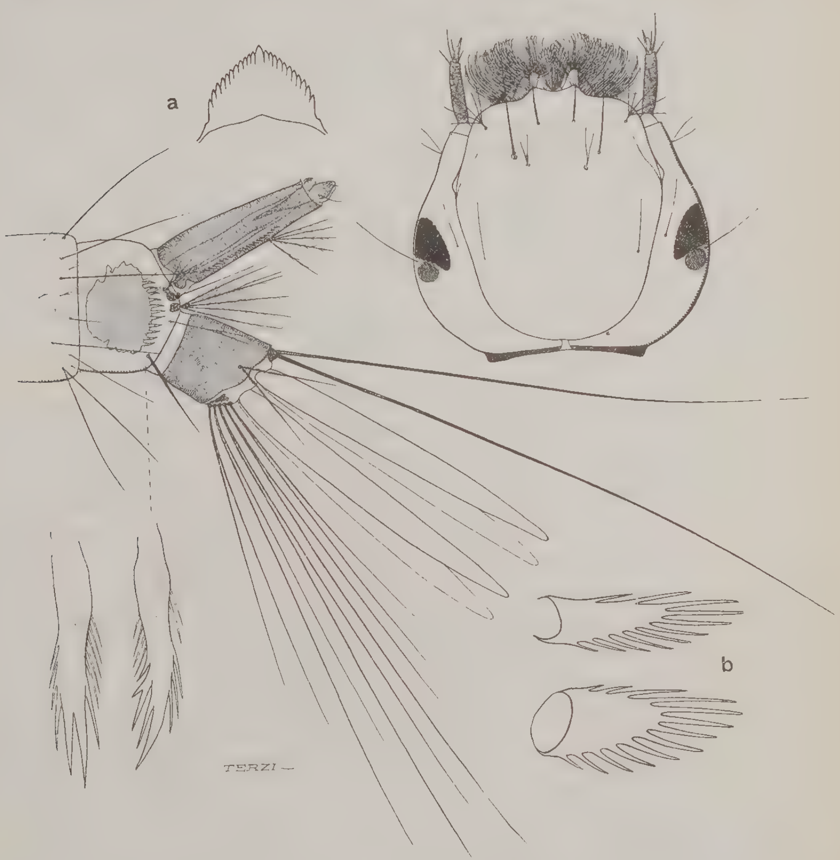


Fig. 5. *Uranotaenia inornata,* Theo., head and terminal segments of larva: *a,* mental plate; *b,* scales of pecten.

dorsal hairs situated far forwards, the pre-antennal hairs of Lang single, stout, long and tapering, the outer post-antennals being tufts of about five hairs, the mid post-antennals and the inner post-antennals placed rather close together, the former represented by a single, long, slender hair, and the latter by a very small delicate hair. Eyes large, situated in the angles at the widest part of the head. Mental plate (fig. 5, *a*) very dense, furnished with numerous very small teeth, the central one somewhat larger than the others.

*Thorax* broad, about 1 mm., bearing large tufts of subplumose hairs and dorsally, on each side of the middle third, two very long black pubescent hairs which reach forwards beyond the anterior margin of the head. All the larger thoracic setae arise from chitinised tubercles.

*Abdomen* not very hairy. Lateral abdominal setae long and triple on the first two segments, thereafter single and smaller. Comb (fig. 5) composed of about a dozen spines set in a transverse row at the margin of a large chitinous plate on the lateral aspect of the eighth segment, the spines are rather feebly chitinised, and have a large pointed median barb and a fringe of smaller barbs on each side of it. The siphonal tuft is small and triple; the subsiphonal large, composed of about five plumose hairs; and the anal single. The siphon (fig. 5) is dark and rather highly chitinised, length (about 0·6 mm.) nearly four times the basal diameter, bearing a pair of large tufts of three to six subplumose hairs a little beyond the middle, and tapering slightly distally to those tufts. The pecten commences a little above the base of the siphon, extending beyond the hair-tufts to about two-thirds of the length of the siphon, and is composed of from fifteen to twenty spines. The spines are feebly chitinised, barbed, and set closely together in a row; they are rather difficult to see since they do not stand out clearly, the surface of the siphon itself being marked with a scale-like development of the chitin. Anal segment highly and completely chitinised, about as long as broad. On each side, near the middle of the posterior margin, is a large double pubescent hair. The beard is very poorly developed. The dorsal hairs are, however, well developed and very long (about 2 mm.), one above and one or two below on each side. The papillae are long, subequal, about 0·9 mm. in length, and nearly four times as long as the anal segment, tapering regularly to pointed extremities.

*Diagnosis.*—This larva apparently resembles that of *U. nigripes*, to which brief reference has been made by Edwards (Bull. Ent. Res. vii, p 15, footnote), both in the position of the frontal hairs and in the number and form of the comb-scales. One character mentioned by Edwards that may serve for differentiation is the length of the anal papillae, which are apparently considerably longer in *U. inornata*.

Pupa.—The pupa is small, length about 3·5 mm. when extended, highly chitinised, and very dark-coloured. The following description is based on the examination of a single pelt.

*Cephalothorax* very dark. Respiratory trumpets (fig. 6, *a*) very dark, short, length about 0·3 mm., straight, with a rather small opening; ratio of the length of the meatus to the total length of the trumpet about 1 to 1·3. Cephalothoracic setae well developed; dorsal setae forming tufts of about five hairs.

*Abdomen* (fig. 6, *b*) not so dark as the cephalothorax. Paddles of the somewhat triangular shape characteristic of the genus, length about 0·5 mm., greatest breadth about 0·34 mm., ratio 1·4 to 1. The midrib is well developed, the external buttress almost indistinguishable; the distal half of the paddles bears on both inner and outer margins small denticules or fimbriae. The single seta at the distal end of the midrib is short, length about 85$\mu$, stout, slightly curved at its end.

The arrangement of the abdominal setae, except in the following instances, calls for no special mention. The lateral setae (A) on segment viii are large tufts, about half the length of the paddles, composed of nine subplumose hairs which are occasionally branched at their tips; on segment vii small, insignificant tufts of two or three hairs; on segments v and vi long single hairs; and on segments iii and iv similar but shorter and more delicate single hairs. The sublateral setae (B) on segments iv to vi are long, single or double, reaching across the following segments or further; on segment vii they are smaller, reaching only about half-way across the eighth segment. The submedian setae (C) on segments iv and v are long, single hairs, reaching beyond the posterior margin of the following segments; on segments

vi and vii shorter, single hairs, reaching about half-way across the following segments. The dendritic tufts (fig. 6, *c*) on segment i are large, composed of about ten primary branches. On segment ii there are small dendritic tufts similar to those found in the genus *Culex*.

*Habitat*.—Kpong, iv.1922; larvae collected from rock-pools near the River Volta. The pools were fully exposed to the sun, and the water in them was very hot. Mosquito larvae, mostly of *Aëdes* (*S.*) *vittatus*, abounded in these pools, and with them were a few larvae of *U. inornata*.

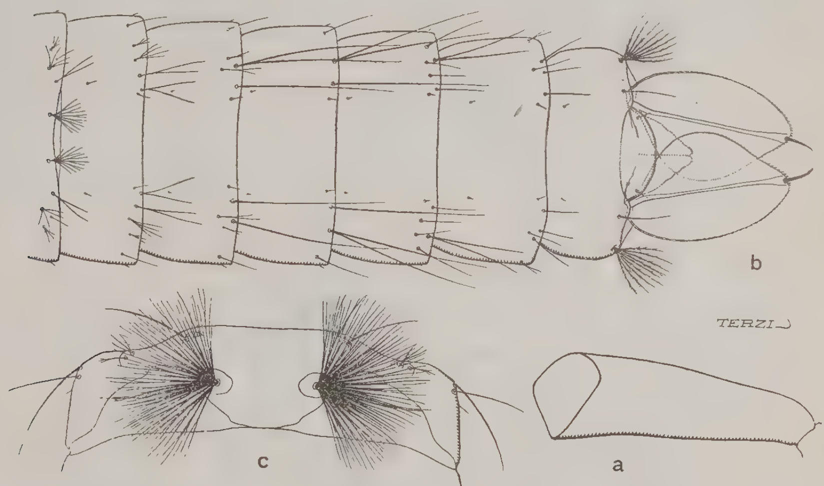


Fig. 6. Pupa of *Uranotaenia inornata*, Theo.: *a*, trumpet; *b*, dorsal view of abdomen; *c*, dendritic tufts on first segment of abdomen.

**Eretmopodites chrysogaster,** Graham.

Larva.—Edwards (Bull. Ent. Res. iii, p. 47) has figured without description the larvae of *E. chrysogaster*, but the drawings are on a small scale and do not show certain important points. He has elsewhere (Bull. Ent. Res. iii, p. 385) mentioned in a key a few points distinguishing this larva from that of *E. inornatus*, Newst. We have in our possession a considerable number of larvae of this mosquito and larval pelts of specimens actually bred through to the adult stage. In some respects, for example, in having no lateral tuft on the seventh abdominal segment and in having a small tuft on the siphon, these specimens differ from those examined by Edwards, and for this reason a short description of them will be given.

Length, 9 to 12 mm.

*Head* (fig. 7) highly chitinised, not very large, without conspicuous hair-tufts. In lateral view oval; in dorsal view rounded and rather narrow anteriorly, broader posteriorly, with rounded posterior angles. Greatest breadth slightly more than the length, but less than the breadth of the thorax (ratio 3 to 5). On the anterior portion of the dorsum and on each side are three setae arranged in a triangle; the anterior one rather long, single; the internal, small, delicate, double; the external, rather longer, double. The dorso-lateral seta situated on a level with the base on the antenna on each side, long, single or double. There are a few other setae on the head, all quite small, one of which arises in the posterior eye spot. Antenna (fig. 7, *a*) dark brown, cylindrical, short, scarcely projecting as far forwards as the ends of the mouth-brushes; not spiculated and without hair-tuft, but bearing at about its

middle and on its inner aspect a single hair. Mental plate (fig. 7, *b*) traingular, highly chitinised, with a moderately large pointed central tooth and seven or eight small pointed teeth on each side of it.

*Thorax.* Setae on the anterior third (first thoracic segment) small; the one most highly developed is situated dorso-laterally, arising from a small chitinous plate and single. On the middle third the dorso-lateral seta is well developed, long, strong, single; the lateral tuft is double, composed of a long single seta dorsally and three similar setae ventrally arising from contiguous chitinised tubercles. On the posterior third there appears to be no dorso-lateral seta; the lateral tuft is similar to that on the middle third but having only two large setae arising from the more ventral tubercle.

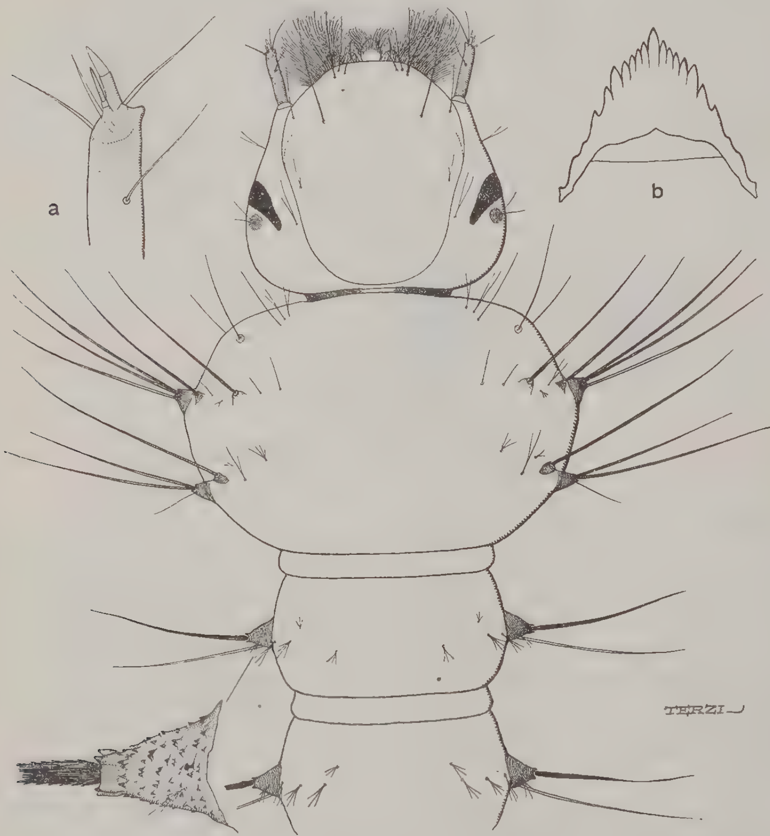


Fig. 7. Larva of *Eretmopodites chrysogaster*, Graham, anterior portion of body: *a*, antenna; *b*, mental plate.

*Abdomen.* The abdominal setae are small and inconspicuous, with the exception of the lateral elements. On each side of segments iii to v are, dorsally a stout, relatively short, single seta arising from a well-developed conical chitinised tubercle, and ventrally a more delicate single seta arising from a small tubercle; on segments i and ii these two setae are situated close together and dorsally, and arise from a common double chitinised tubercle; from segment vi the ventral seta is absent;

on segment vii only small delicate hairs are present ; and on segment viii are a well developed tuft (the subsiphonal tuft) ventral to the siphon, composed of 3 to 7 subplumose hairs, two very small tufts dorsally, at the base of the siphon, and a very small delicate tuft at the base of the anal segment. Comb (fig. 8) composed of about thirty (19 to 33) spines arranged in an irregularly triangular patch ; each spine is highly chitinised, with several sharply pointed teeth, one of which is usually somewhat longer and larger than the others. Siphon (fig. 8) well chitinised, dark brown, short, and forming with the eighth segment an angle extremely obtuse anteriorly ; ratio of length to basal breadth about 2 to 1. Pecten composed of 1 to 4 dark brown barbed spines. Tuft on the siphon small, situated a little proximal to the middle, composed of two or three subplumose hairs. Anal segment short, with a small dorsal saddle-shaped chitinous plate. Posterior dorsal setae about as long as the anal papillae, strong, subplumose, usually single or double above and below on each side. Lateral seta small, a delicate tuft of hairs. Subventrally on each side at the posterior end of the anal segment is a row of four strong graded subplumose setae arising from a common chitinised plate. Anal papillae subequal, long and broad, tapering slightly at their ends ; nearly twice the length of the siphon and more than twice that of the anal segment. The anal papillae are very frequently missing.

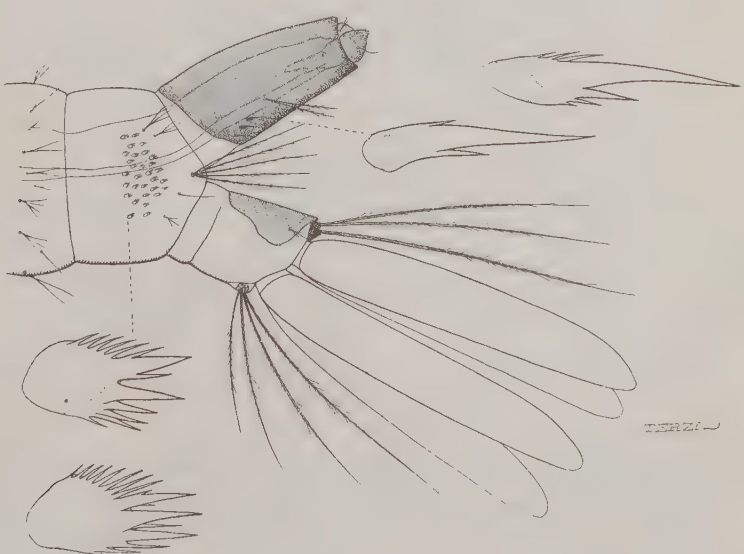


Fig. 8. Larva of *Eretmopodites chrysogaster*, Graham, terminal segments.

Pupa.—Edwards (*loc. cit.*) has also figured the pupa, but the remarks made when dealing with the larva apply also to this figure. Bacot has figured the paddles and the terminal segments only. A fuller description of the pupa will therefore be given.

Length, when fully extended, 7 mm. to 8·5 mm. The pupa is well chitinised, and its general form is well shown in Edward's figure.

*Cephalothorax* well chitinised. Wing-cases rather loosely attached to the sides. Respiratory trumpets (fig. 9 *a*) shaped like the corolla of a foxglove, opening not very wide ; length about 0·7 mm., ratio of length of the closed portion (meatus) to total length about 1 to 1·4. Cephalothoracic setae arranged much as in *Aëdes argenteus* (*Stegomyia fasciata*). Post-ocular and antero-thoracic setae very small and inconspicuous. Dorsal setae long, strong, single ; slightly subplumose and often divided

at the end. Supra-alar seta a small tuft of about five fine hairs. Postero-thoracic setae: internal and median, long stout black setae, subplumose, single; external, a small tuft of about five delicate hairs.

*Abdomen.* The paddles (fig. 9, *c*) are relatively small, and bear a long fringe on both the inner and outer borders; length averaged in five specimens 716 $\mu$, greatest breadth 496 $\mu$, the ratio being about 1·4 to 1. Midrib moderately well developed. At the distal end, slightly to the outer side of the midrib, is a long, subplumose, single seta (P′); length averaged 537 $\mu$, that is, rather more than the breadth of the paddle; this seta is sometimes divided at its end into a number of hairs, when this is the case it is much shorter.

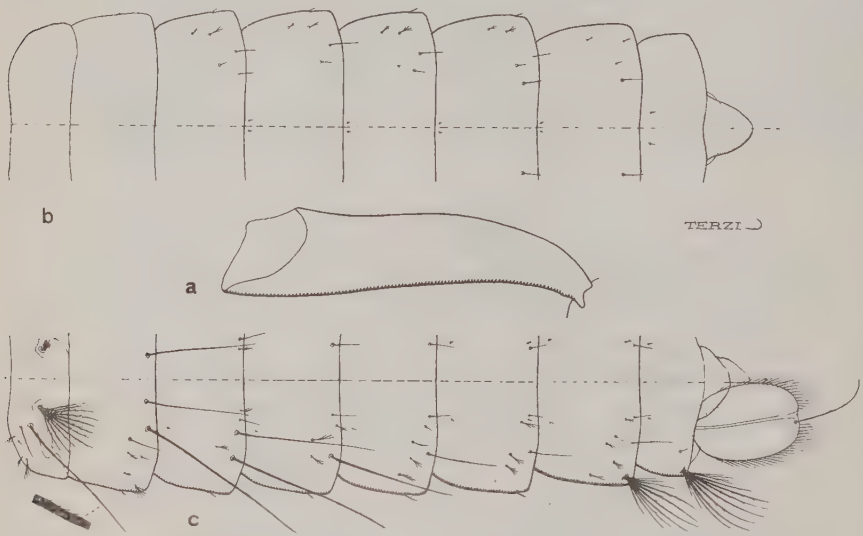


Fig. 9. Pupa of *Eretmopodites chrysogaster*, Graham: *a*, trumpet; *b*, ventral view of abdomen; *c*, dorsal view of abdomen.

Dorsal abdominal setae arranged as shown in the diagram (fig. 9, *c*). There are eight setae on each side of each of the segments from the first to the seventh; on the eighth are only three. Most of the setae are small inconspicuous tufts, and therefore only the more important will be mentioned. The lateral seta (A) on segments ii to vi minute, single; on segment i apparently slightly longer; on segment vii well developed tufts, as long as or longer than the eighth segment, composed of about six (three to seven) dark, subplumose hairs; on segment viii larger tufts, rather longer than the paddle, composed of about six (four to nine) dark, subplumose hairs; both the latter tufts often have additional small subsidary basal hairs. The sublateral setae are recognisable on segments iii to vii at least; on segments v to vii they are moderately stout and long, extending about half-way across the succeeding segment; on segments iii and iv they are long, strong, black setae, slightly subplumose, extending considerably beyond the posterior margin of the succeeding segments. On segment iii a little internal to the sublateral seta is a similar long, strong, black seta. On segment ii this seta and the sublateral seta are apparently displaced inwards; both setae are similar to the sublateral setae on segments iii and iv, but the inner one is rather shorter. The submedian setae are not highly developed; in this situation, on segments iii to vii, are small stout single setae. The tuft on

segment i is moderately well developed, and is composed of about ten (six to thirteen) dark plumose hairs ; the antero-internal seta is small but stout ; the antero-external long, strong, black, slightly subplumose.

Ventral abdominal setae all very small and inconspicuous ; arrangement as in *Aëdes argenteus* (*Stegomyia fasciata*). Postero-lateral and medio-lateral small tufts. The arrangement of the setae is shown in the diagram (fig. 9, *b*).

*Habitat.*—Aburi, 21.xi.1920, in cut bamboos, and in small collections of water in banana leaves lying on the ground ; Koforidua, vii.1916, in pawpaw tree stump ; Nsawam, 1.i.1920, in disused tins near the Rest House and in a hollow stump of a pawpaw tree ; Taimang, 18.iii.1922, in pawpaw tree stumps.

**Eretmopodites quinquevittatus,** Theo.

Larva.—The larva is similar to that of *E. chrysogaster*, and it is therefore only necessary to describe the more important points of difference.

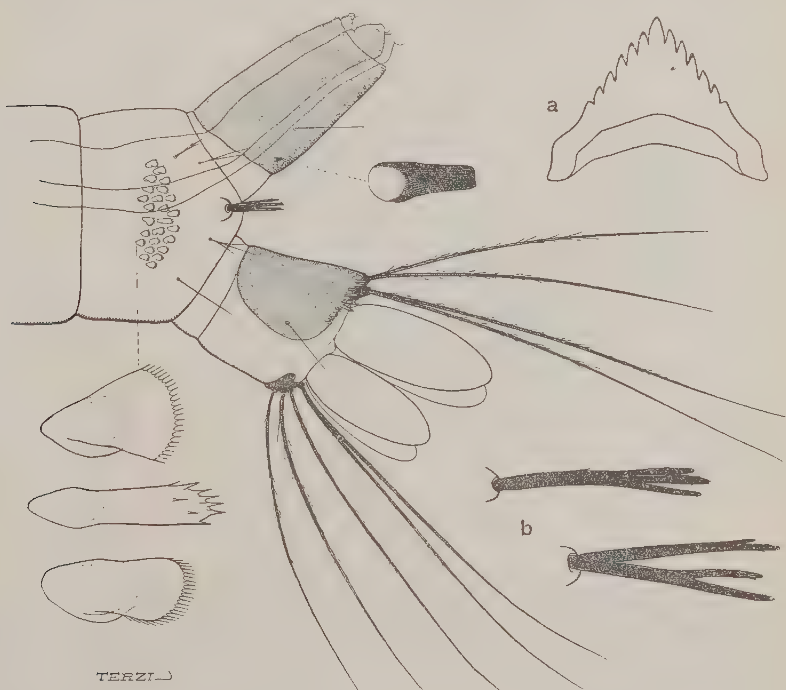


Fig. 10. Larva of *Eretmopodites quinquevittatus*, Theo., terminal segments of abdomen : *a*, mental plate ; *b*, subsiphonal setae.

The head is smaller and narrower, the greatest breadth almost the same as the length, and about half the diameter of the thorax. Mental plate (fig. 10, *a*) with, apparently, six teeth on each side of the middle tooth. The dorso-lateral setae on the middle third of the thorax more highly developed and forming a large tuft, half of which is composed of short and half of long hairs. There are no short, stout setae on the sides of the abdomen similar to those of *E. chrysogaster*. The subsiphonal tuft is, however, a short, stout, dark-coloured seta arising from a chitinised tubercle and divided into two or three tapering branches (fig. 10, *b*). The comb is composed of about twenty-five small scales arranged in a triangular patch ; each scale is short,

feebly chitinised, and finely fringed at its blunt distal end. The siphon (fig. 10) is shorter than that of *E. chrysogaster*, and is less than twice as long as the basal breadth, the ratio of length to basal breadth being about 1·5 to 1; it bears in place of a tuft a single long seta on its basal third, and has either no pecten or only a single spine. The dorsal and subventral setae at the posterior margin of the anal segment are longer than in *E. chrysogaster*.

*Diagnosis.*—The larva of *E. quinquevittatus* may be distinguished from that of *E. chrysogaster* by the characters given above. We have not had an opportunity of examining the larva of *E. inornatus*, the only other African species of which the larva has apparently been described, but from the characters given by Edwards it is clear that it more closely resembles *E. quinquevittatus*; indeed the only point mentioned which might serve to separate them, namely, the two-haired tuft on the siphon of *E. inornatus*, is not likely to be sufficient, if one may judge from the range of variations of this tuft in other mosquitos.

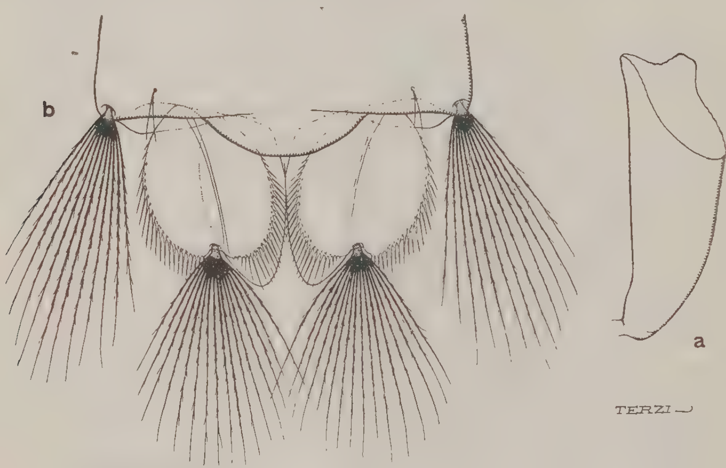


Fig. 11. Pupa of *Eretmopodites quinquevittatus*, Theo.: *a*, trumpet; *b*, paddles.

Pupa.—The chief differences between the pupae of *E. quinquevittatus* and *E. chrysogaster* are as follows:—In *E. quinquevittatus* the respiratory trumpets (fig. 11, *a*) are shorter, length about 0·5 mm.; the ratio of the length of the meatus to the total length is, however, unchanged, namely, about 1 to 1·4. One seta on the cephalothorax is especially well developed, and composed of two to four long, stout, black, pubescent branches; this seta is apparently the median post-ocular seta, but as both the specimens examined were pelts we were unable to be certain of this. The paddles (fig. 11, *b*) are relatively very small and bear a long fringe; length about 390 $\mu$, greatest breadth about 360 $\mu$. In the male the sheaths of the claspers project posteriorly beyond the ends of the paddles. At the distal margin, slightly to the outer side of the end of the midrib, is a very large tuft composed of ten to seventeen long, subplumose, black hairs; this tuft is about 0·7 mm. to 0·8 mm. long, that is, much longer than the paddle. The dorsal abdominal setae are similar to those of *E. chrysogaster*, but the lateral setae on segments vii and viii are rather larger and more subdivided; the sublateral setae on segment vii very small and inconspicuous, on segments iv to vi larger than in *E. chrysogaster*; and the other strongly developed setae smaller than those of *E. chrysogaster*. The tufts on segment i are smaller and

less expanded, composed of five to seven subplumose hairs. The rest of the abdominal setae do not apparently call for special mention.

*Diagnosis.*—The smaller size of the paddles and the large tufts at their distal ends suffice to distinguish this pupa from those of other known species of *Eretmopodites.*

*Habitat.* —Accra, 26.vii.1921, in water collected in disused tins near the European Hospital.

**Ficalbia mediolineata,** Theo.

LARVA.—The length of the larva when fully grown is about 5 mm. It is pale-coloured, with a bronze-brown siphon and conspicuous dark lines on the anterior lateral angles of the thorax due to the coiled respiratory trumpets of the pupa which show through the larval cuticle.

*Head* (fig. 12) broad, length nearly 0·8 mm. and greatest breadth about 0·9 mm. Antennae somewhat similar to those of *Mimomyia hispida,* long, slightly curved, not at all infuscated, bearing at about the middle a large tuft of plumose hairs, and covered (especially basally) with large spicules. The pre-antennal hairs of Lang are very small tufts, the outer post-antennals large tufts of about a dozen plumose hairs, the inner and mid post-antennals longer tufts of similar plumose hairs, the former composed of five, and the latter of three hairs. The mental plate (fig. 12, *a*) is small, rather flat, with a large, pointed, central tooth, and on each side of it about eight smaller teeth, the most lateral of which are the largest.

*Thorax* broad; lateral tufts long and composed of plumose hairs, those on the middle and posterior thirds with well developed basal spines.

*Abdomen* not very hairy. Lateral abdominal setae long and plumose basally. Comb composed of about twelve small fringed spines arranged in a transverse row. Siphonal tuft composed of two or three rather long hairs, subsiphonal of four or five pubescent hairs, and anal of about four more delicate branches. The siphon has a narrow, dark, basal band; length (about 1·2 mm.) eight times the basal diameter; hair-tuft, composed of two rather long simple hairs, situated at about the junction of the middle and posterior thirds; apparently without pecten. Anal segment highly chitinised, the dorsal side of the chitinised area about twice as long as the ventral, covered dorsally with spicules which are long near the posterior border; on each side near the middle of the posterior margin is a long, strong, single or double seta. Beard very small; dorsal setae well developed, three or four above and below on each side. Anal papillae very small (length about 0·15 mm.), with pointed ends.

PUPA.—The pupa is about 4 mm. long when extended. When alive it rests at the surface of the water with the two very long respiratory trumpets directed forwards and either submerged with the long dorsal hairs of the second to fourth abdominal segments directed upwards and forwards and just reaching the surface film, or with the cephalothorax slightly depressed, a fact with which should be correlated the obsolete condition of the dendritic tufts on the first abdominal segment. It is rather top-heavy owing to the length of the trumpets.

*Cephalothorax.* Respiratory trumpets (fig. 13, *a*) straight, very long and narrow, dark brown, except the extreme base and the apical one-fifth or one-sixth, which is white. Length about 2·7 mm., breadth in the middle about 70 $\mu$; proximal end slightly wider, distal extremity with a narrow neck and a funnel-shaped opening. The ratio of the length of the meatus to the total length of the trumpet is about 1 to 1·1. The cephalothoracic setae are rather poorly developed and do not call for special mention, the dorsal setae are single and short.

*Abdomen* (fig. 13, *b*). The paddles are long and very narrow, length about 0·9 mm., greatest breadth about 0·15 mm., ratio 6 to 1. The midrib is well developed, but the external buttress is practically wanting; there are no terminal setae, and the

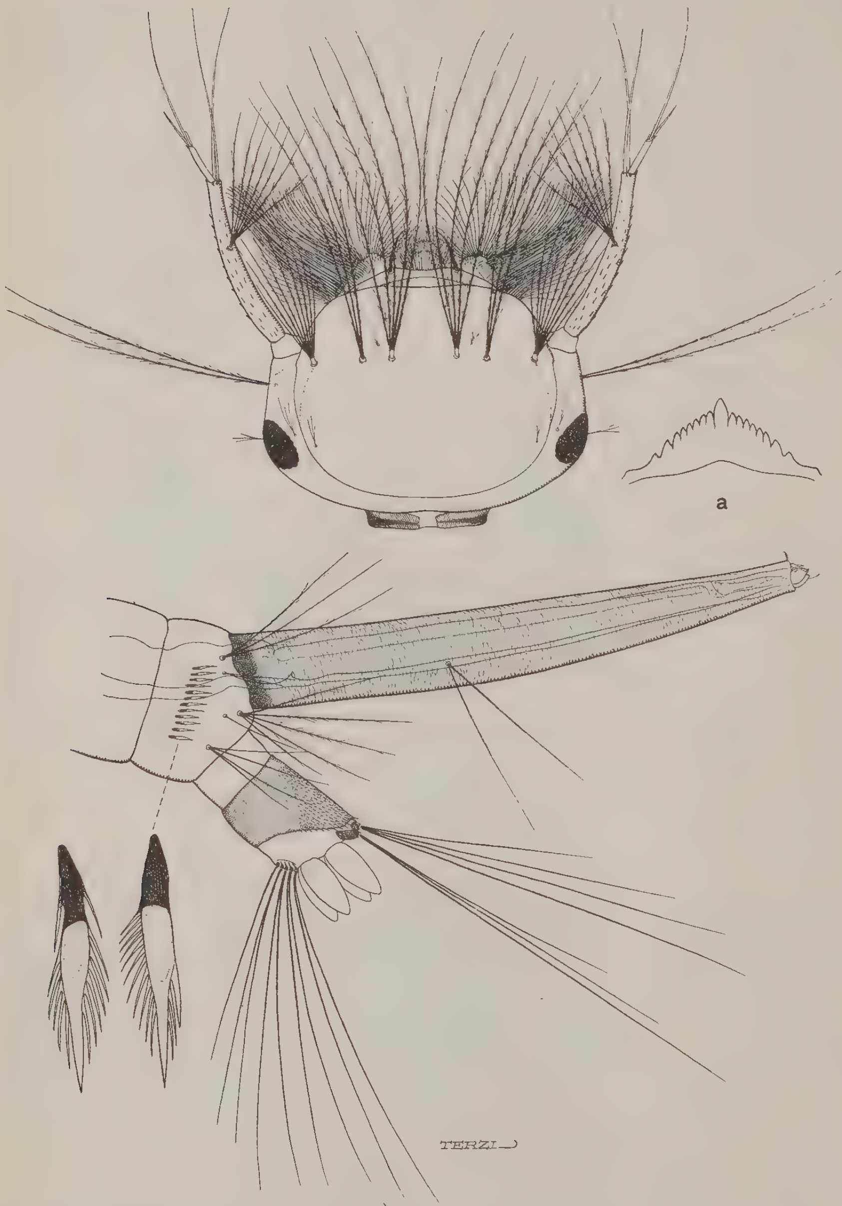


Fig. 12. Larva of *Ficalbia mediolineata*, Theo., head and terminal segments of abdomen: *a*, mental plate.

fringe, which is composed of large tooth-like processes, extends completely round the paddles with the exception of the extreme base. The ninth segment is unusually large and in the female is furnished with two lateral processes covered by coarse spicules (fig. 13, *c*, *d*). The dorsal abdominal setae are well developed, the more important ones being conspicuous black tufts. The lateral setae (A) on segment viii are large tufts, reaching nearly to the middle of the paddles, composed of eight or nine pubescent hairs, on segment vii smaller tufts of two or three similar hairs, and on segments ii to vi very long, delicate, single hairs. The sublateral setae (B) on segment vii are tufts, reaching beyond the posterior margin of the eighth segment, of four pubescent hairs; on segments iv to vi similar but longer tufts of three hairs. The submedian setae (C) on segment vii are very long tufts, reaching backwards beyong the middle of the paddles, composed of three pubescent hairs; on segments iii to vi similar but shorter tufts of three hairs. The dendritic tufts on segment i are obsolete, being represented by small, stout, single setae.

*Habitat*.—Accra, v.1922; collected from a pool covered by water lettuce (*Pistia stratiotes*), near the station for the Weshiang railway line.

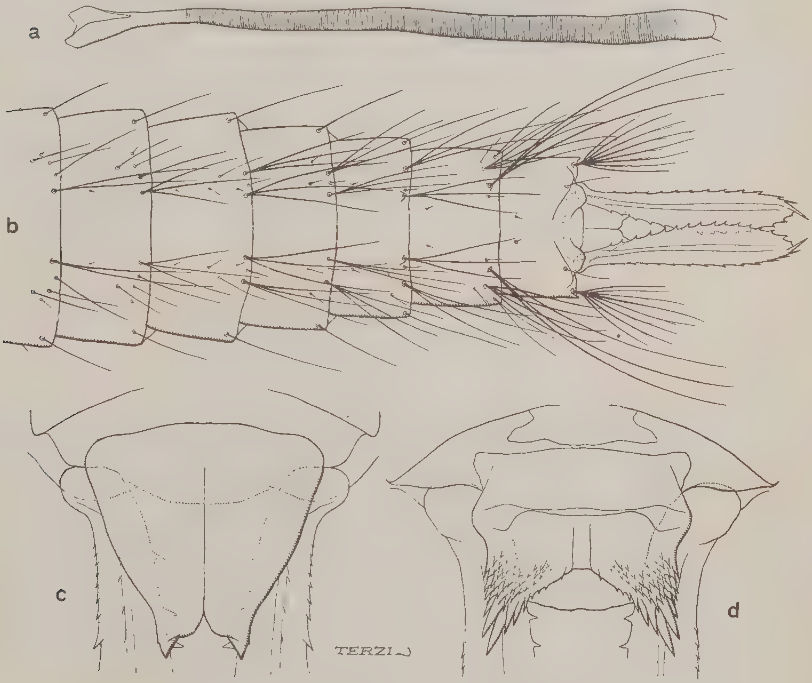


Fig. 13. Pupa of *Ficalbia mediolineata*, Theo.: *a*, trumpet; *b*, dorsal view of abdomen; *c*, ninth abdominal segment of ♂; *d*, same of ♀.

**Aëdes (Aëdimorphus) furcifer**, Edw.

Larva.—The larva has not yet been identified.

Pupa.—Only a single pupal pelt was obtained, and as some setae were missing from it a complete description cannot be given. The pupa is well chitinised and not very large; length when extended about 5 mm.

*Cephalothorax.* The respiratory trumpets (fig. 14, *a*) are short, narrowed both apically and basally, slightly infuscated basally, and with narrow apertures; length about 0·5 mm., middle breadth about 120 $\mu$, ration of the length of the meatus to the total length about 1 to 1·26.

*Abdomen.* The paddles (fig. 14, *b*) are oval and small; length about 0·6 mm., greatest breadth about 0·4 mm., only slightly more than half the breadth of the eighth abdominal segment. The external buttress is practically absent. The midrib is feebly developed and divides the paddle into two approximately equal halves. There is no fringe, but the posterior and external borders of the paddles bear a few small denticulations. The distal hair was unfortunately missing from both the paddles, but there appeared to be a socket for a large seta on the outer side of each midrib.

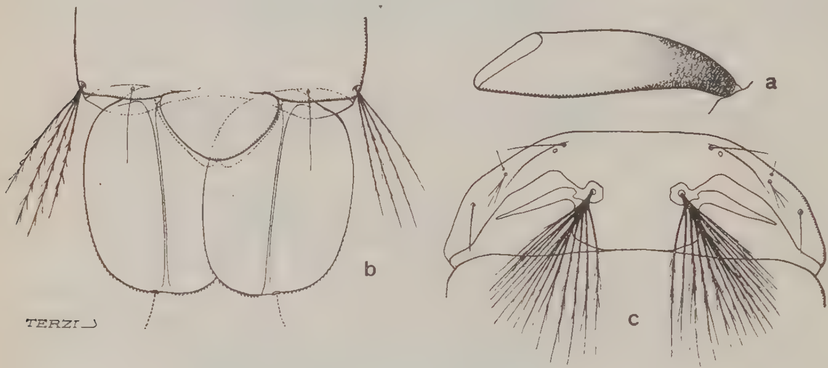


Fig. 14. Pupa of *Aëdes furcifer*, Edw.: *a*, trumpet; *b*, paddles; *c*, dendritic tufts on first abdominal segment.

The lateral setae on segment viii are tufts of about four stout, subplumose hairs, which are long, the longest reaching not far short of the posterior extremities of the paddles; on segment vii small tufts of two stout, pubescent hairs; on segment vi missing, but provided with large sockets; and on segments v to iii delicate, simple, single hairs. The sublateral and submedian dorsal setae apparently are situated unusually near the middle line on the more anterior segments. The sublateral setae on segments vi and vii are short single hairs, and on segments iii to v long stout hairs reaching beyond the posterior margins of the following segments. The submedian setae on segment vii are small single hairs (on one side the hair is divided at its tip), on segments v and vi small double hairs, and on segments ii to iv larger triple hairs. The large tufts (fig. 14, *c*) on segment i are of an unusual form, being stout, branched setae with a median stem giving off about fifteen subplumose hairs.

*Diagnosis.*—This pupa differs in some respects very notably from the other known pupae of West African species of *Aëdes* (*Ochlerotatus*), for example, in the forms of the respiratory trumpets, the paddles, and the large tufts on the first abdominal segment. Moreover, the smaller tufts on the second segment are absent, being replaced by triple (or quadruple) hairs, and in this respect, as well as in others, the pupa more closely resembles that of *Aëdes* (*Stegomyia*).

*Habitat.*—Accra, 15.vii.1921; one female reared from a pupa obtained from water in a rot-hole in a flamboyant tree (*Poinciana regia*) in the compound of a bungalow.

**Aëdes (Aëdimorphus) irritans,** Theo.

LARVA.—The larva has already been described (Bull. Ent. Res. vii, p. 5).

PUPA.—The pupa is of moderate size, length about 4 mm. when extended.

*Cephalothorax.* The respiratory trumpets (fig. 15, *a*) are about 0·4 mm. long; they are rather narrow and have small apertures. The ratio of the length of the meatus to the total length of the trumpets is about 1 to 1·2. The cephalothoracic setae are all small, the dorsal setae being small tufts of two or three hairs about half the length of the trumpets.

*Abdomen* (fig. 15). The paddles, which are nearly 0·7 mm. long, are oval, the ratio of length to greatest breadth being about 1·3 to 1; they are supported by a well-developed midrib and a rather ill-defined external buttress. The terminal seta is single, long, nearly one-third the length of the paddle (about 0·2 mm.), and usually slightly curved at its extremity. There is no proper fringe, but only a few denticulations along the external borders of the paddles.

The lateral setae (A) of the abdomen are highly developed only on segments vii and viii; on the other segments they are rather long and delicate single or double hairs. On segment viii they are well-developed tufts composed of from two to six subplumose hairs, the longest hairs being about half the length of the paddles. On segment vii they are smaller tufts of two or three pubescent hairs. The sublateral setae (B) on the dorsal surface of segments iv to vi are long, reaching to about the posterior border of the following segment, single or double. The submedian setae are rather small on all segments, and are composed of one to four fine hairs. The other setae, which are mostly small, call for no special mention. In the male the cases for the claspers are very large and long.

*Diagnosis.*—See *Aëdes* (*Ochlerotatus*) *wellmani*.

*Habitat.*—Accra; abundant at all times of the year in crab-holes and in collections of brackish water.

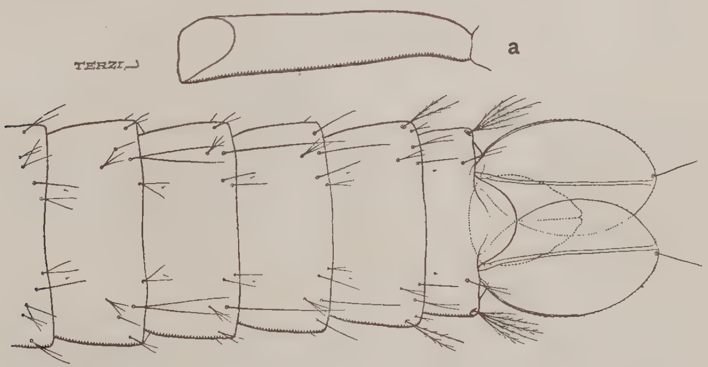


Fig. 15. Pupa of *Aëdes irritans*, Theo., dorsal view of abdomen: *a*, trumpet.

**Aëdes (Finlaya) wellmani,** Theo.

LARVA.—*Head* not strongly chitinised and not large relatively to the thorax. Mouth-brushes rather conspicuous. The antenna is stout and curved, with the convexity external, sparsely covered with spicules; hair-tuft situated about three-sevenths of the length of the shaft from the base, and composed of six or more subplumose hairs. The shaft of the antenna tapers gradually from the insertion of the hair-tuft to the apex. The ante-antennal tuft (outer post-antennal of Lang)

consists of about ten to twelve subplumose hairs. The three hairs on each side of the middle line on the dorsum are large, multiple, and subplumose, the inner (pre-antennal) one composed of about fourteen to sixteen hairs, the posterior (inner post-antennal) of five hairs, and the anterior (middle post-antennal) of six hairs. There is a large lateral hair-tuft posterior to the ante-antennal tuft consisting of subplumose hairs. The mental plate has a stout central tooth, on either side of which are ten or eleven more slender teeth, those nearest the central tooth being more closely approximated and narrower than those situated more externally.

*Thorax.* The thoracic plumes are fairly well developed, the constituent hairs being subplumose; the main plumes rise from chitinous bosses.

*Abdomen.* The dorso-lateral hairs are long, paired, subplumose. Numerous stellar hair-tufts are present on all the abdominal segments. The siphonal, sub-siphonal, and anal plumes are composed of subplumose hairs. All these plumes are well developed and rise from chitinous sockets. The comb is formed of about eight pointed teeth, without secondary barbs but with a delicate fringe basally, placed in a curved row. The siphon is well chitinised, about three times as long as the diameter of its basal ring. It bears a pecten of about twenty spines which extends over rather more than one-third (five-twelfths) of its length; these spines have a secondary barb at their base and are somewhat irregularly placed. The tuft on the siphon is formed of four or five hairs, which are almost simple, and is situated at about the middle of the tube. The anal segment is irregularly chitinised over a saddle-shaped area. On each side at its posterior border is a long stout double seta. The beard is poorly developed. The dorsal hairs at the distal end of the anal segment appear to be four above and one below on each side, the latter being very long and stout. The anal papillae are well developed, about two and a half times the length of the anal segment, and have rounded extremities.

*Diagnosis.*—This larva may be distinguished from other known African *Aëdes* (*Ochlerotatus*) larvae by having the median hairs on the head multiple, a comb of about eight spines, and a pecten of about twenty spines.

Pupa.—The pupa is rather small and not very highly chitinised.

*Cephalothorax.* The respiratory trumpets are highly chitinised and shagreened. The cephalothoracic setae are similar to those of *Aëdes* (*S.*) *argenteus* (Bull. Ent. Res. x, pp. 161–164).

*Abdomen.* The paddles are oval, about 0·9 mm. long; the ratio of length to greatest breadth is 1·6 to 1. The midrib is well developed and divides the paddle into two approximately equal parts. There is a single, long, stout seta, about 0·1 mm. in length, at the distal end of the midrib. The external buttress is rather feebly developed. The paddle is not furnished with a definite fringe but bears a few short hairs or fimbriae along its posterior border.

The arrangement of the dorsal abdominal setae is similar to that in *Aëdes* (*S.*) *argenteus* (*loc. cit.*, pp. 164–167). Mention need only be made of the more important of them: the lateral setae (A) are delicate and single on segments i to vi, on segment vii relatively stout single or double setae reaching to about the middle of the succeeding segment, and on segment viii well developed tufts, about half the length of the paddle, composed of about six subplumose hairs, some of which are branched. The sublateral setae (B) are long and single, on segments ii and iii rather delicate, on segments iv and v stouter and longer and reaching backwards to about the middle of the next segment but one, on segment vi stout but rather shorter and reaching nearly to the posterior margin of the succeeding segment, and on segment vii rather stout but not reaching beyond the middle of the next segment. The dendritic tufts on segment i well developed, those on the second segment smaller but characteristic. The ventral abdominal setae are small and inconspicuous and are similar to those of *Aëdes* (*S.*) *argenteus* (*loc. cit.*, pp. 167–169). The abdominal stigmata are conspicuous.

*Diagnosis*.—The pupae of *Aëdes* (*O.*) *irritans* and *Aëdes* (*O.*) *wellmani* fall into the group in our provisional key (Bull. Ent. Res. viii, pp. 81–82) which includes *A.* (*O.*) *apicoannulatus* and *A.* (*O.*) *simulans*. Bacot's figure of *A.* (*O.*) *apicoannulatus* does not show any features which would distinguish this species from *A.* (*O.*) *irritans*, since both have long (about 0·2 mm.) terminal setae on the paddles and a fringe composed of "excessively minute and delicate" serrations, but specimens in our collection show the following differences: the dorsum of the cephalothorax and the respiratory trumpets are more deeply infuscated; the respiratory trumpets are larger, length about 0·48 mm., and the ratio of the length of the meatus to the total length is about 1 to 1·4; the cephalothoracic setae are larger, the dorsal setae being large tufts of two to five hairs almost as long as the trumpets; the fringe of denticulations on the paddles is more pronounced; and the abdominal setae are more highly developed, the sublateral setae on segments iv to vi reaching fully or almost fully across the two following segments. The terminal setae on the paddles of *A.* (*O.*) *wellmani* might serve to separate this species from the other three, since they are relatively short (about 0·1 mm.) and single. *A.* (*O.*) *simulans*, as figured by Bacot, has the terminal seta on the paddles bifid, no fringe and the lateral setae on segment vii not differentiated as tufts; but the first character may be variable (as it is in some other species), and as regards the other two the figures may be misleading owing to the relatively low magnification at which they are drawn. Bacot's figures are not sufficiently detailed to show the sublateral and submedian setae, which may furnish additional, and perhaps more satisfactory, differential points.

*Habitat*.—Aburi, from the hollow in the stem of a cut bamboo, 6.vi.1920.

**Aëdes (Finlaya) longipalpis,** Grünb.

Wesché (Bull. Ent. Res. i, pp. 29–30) described the larva of this mosquito under the name *Stegomyia pollinctor*, Graham, but he had at his disposal only a single damaged specimen, and, as noted by Edwards, the description given is insufficient for identification. Edwards states also that "the specimens in the British Museum are too damaged for purposes of tabulation." As we have in our possession a larva and a larval pelt of this species, it may be advisable to describe them here.

Larva.—The larva measures about 5 mm. to 6 mm. in length when fully grown, and has a very dark brown head and siphon.

*Head* (fig. 16) highly chitinised and very dark brown; length about 0·8 mm., greatest breadth about 1·1 mm. Antennae dark brown, cylindrical, short (about 0·3 mm.), bearing a double hair in place of a tuft, and sparsely clothed with small spicules. Hairs relatively poorly developed; the pre-antennal apparently a very small tuft of about four hairs, the outer post-antennal a double or triple hair, and the mid and inner post-antennals rather long single hairs. Mental plate (fig. 16, *a*) with a large, pointed, central tooth, and on each side of it about sixteen smaller teeth, which increase in size and are more widely separated towards the lateral margin.

*Thorax* slightly wider than the head; lateral hair-tufts moderately well developed and without definite spine-like processes at their bases.

*Abdomen* not very hairy. Dorso-lateral hairs well developed on the first two segments only. Siphonal (fig. 16) and anal tufts small, composed of about five delicate, apparently simple, hairs; subsiphonal tuft larger, composed of about five plumose hairs. Comb a roughly triangular patch of very numerous (? about 100) small fringed scales. Siphon very dark brown, tapering distally and slightly constricted at its base; length about four times the basal diameter. Pecten a row of about seventeen long pointed spines with small basal barbs, reaching to about the middle of the siphon, without detached spines. Hair-tuft composed of about eight delicate hairs, situated a little beyond the end of the pecten. Anal segment slightly

longer than broad; chitinised area saddle-shaped, bearing at its posterior margin a few spicules and a tuft of delicate hairs. Beard moderately well developed. Dorsal hairs at the posterior margin of the anal segment long, four or five above and one below on each side. Anal papillae described by Wesché as unequal, the dorsal pair twice the size of the ventral; in our specimens the dorsal pair are apparently atrophied.

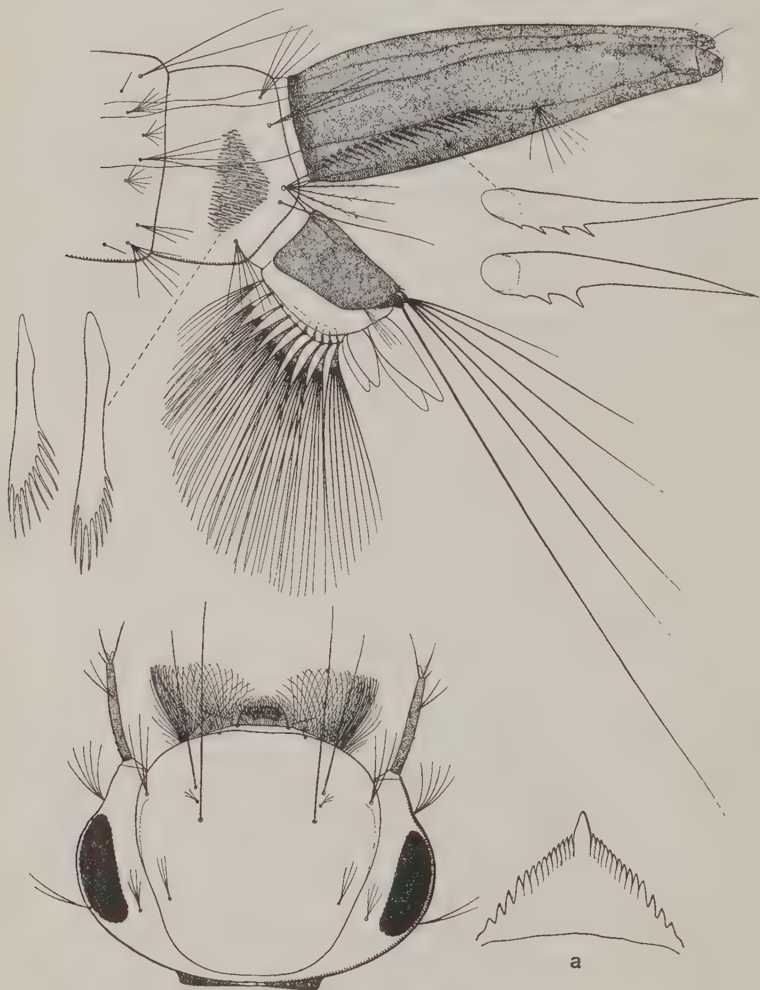


Fig. 16. Larva of *Aëdes longipalpis*, Grünb., head and terminal segments of abdomen: *a*, mental plate.

*Diagnosis.*—This larva according to Edwards's key (Bull. Ent. Res. iii, p. 376) has to be distinguished from those of *Aëdes* (*O.*) *nigeriensis* and *Aëdes* (*S.*) *vittata*, which also have the median hairs on the head single. From both these it may be separated, to mention only one of many characters, by the number of scales in the comb.

PUPA.—The pupa is about 5 mm. long when extended.

*Cephalothorax* somewhat infuscated dorsally and posteriorly. Respiratory trumpets (fig. 17, *a*) very dark brown, short, length about 0·5 mm., straight, with a rather small, slightly constricted aperture ; ratio of length of meatus to total length about 1 to 1·2. Cephalothoracic setae well developed, the dorsal setae rather large tufts of three to six pubescent hairs, about as long as the respiratory trumpets.

*Abdomen.* Paddles (fig. 17) more or less pyriform, small ; length usually about 0·4 mm. (in one specimen 0·7 mm.), ratio of length to greatest breadth about 1·2 to 1. Midrib and external buttress moderately developed ; fringe represented only by minute denticulations. Terminal seta at the end of the midrib usually about one-quarter the length of the paddles (*i.e.*, about 0·1 mm.), and not bifid—in one very large female, however, it was longer, over one-third the length of the paddles.

Dorsal abdominal setae (fig. 17) well developed. Lateral setae (A) on segment viii large tufts, more than half the length of the paddles, composed of about ten or eleven subplumose hairs, on segment vii small tufts of two or three hairs, and on segments iii to vi delicate hairs, usually single but sometimes double or triple. Sub-lateral setae (B) on segment vii small hairs subdivided at the ends, on segments iv to vi long, single or double, pubescent setae which extend backwards slightly beyond the posterior margins of the following segments. Submedian setae (C) on segments iv to vii delicate tufts of usually four hairs, which are rather larger on the more anterior segments ; on segment iii the corresponding seta is also a delicate tuft, rather smaller than that on segment iv, but with more branches, usually about nine. The dendritic tufts on segment i are large and composed of long subplumose hairs, which are branched mainly at their ends ; the tufts on segment ii are rather large, with numerous branches—in the very large female referred to before, the tufts on segment i were practically unbranched, and those on segment ii (as shown in fig. 17) composed of only four or five long unbranched hairs. In the male the cases for the claspers are very large and reach almost to the posterior margins of the paddles.

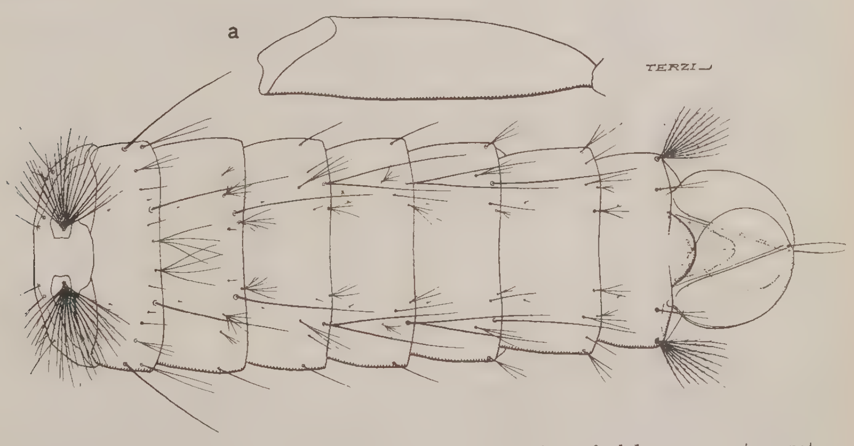


Fig. 17. Pupa of *Aëdes longipalpis*, Grünb., dorsal view of abdomen : *a*, trumpet.

*Diagnosis.*—This pupa falls into the same group as those of *Aëdes* (*O.*) *irritans*, *A.* (*O.*) *wellmani*, *A.* (*O.*) *apicoannulatus*, and *A.* (*O.*) *simulans*, the differential characters of which cannot be given with certainty until further material has been examined to determine the range of variations in the several species. The following

points, which appear to provide distinguishing features, may however be mentioned; in *A.* (*O.*) *simulans*, according to Bacot, the terminal seta on the paddles is bifid; in *A.* (*O.*) *wellmani* the paddles are longer and narrower, and the terminal seta on them is relatively shorter; in *A.* (*O.*) *apicoannulatus* the sublateral setae on the dorsum of segments iv to vi of the abdomen are longer; and in *A.* (*O.*) *irritans* the paddles are larger, the respiratory trumpets shorter, and the dorsal setae on the cephalothorax smaller tufts.

*Habitat.*—Ofako, a village about nine miles north of Accra on the Nsawam road, v.–vi. 1922; larvae found in a rot-hole in a tree in dense "bush." In the same rot-hole were found larvae of *Megarhinus* (*Toxorhynchites*) *brevipalpis*, *Aëdes* (*O.*) *apicoannulatus*, and *C.* (*Culiciomyia*) *macfiei*, Edw., a new species of which the description is published above (p. 399).

**Aëdes (Stegomyia) apicoargenteus,** Theo.

Larva.—The larva resembles that of *A.* (*S.*) *dendrophilus*, but the following differences may be noted. The siphon is perhaps a little shorter, length about twice the basal width, and its apical fourth is paler than the basal three-quarters. The pecten extends in a somewhat curved line for from one-third to nearly one-half the length of the siphon and is composed of about twelve to sixteen spines, which have long sharp points and well-developed basal barbs (fig. 18, *c*). The tuft on the siphon is situated just beyond the last spine of the pecten and is usually double, occasionally single or triple. The hair on each side of the anal segment near the middle of the posterior margin is long, and in all the specimens examined by us, single. The larva also closely resembles that of *A.* (*S.*) *luteocephalus*, and although there are several characters usually unlike—such as the long hair on the siphon in place of a tuft—none of them was constantly different.

Pupa.—The pupa also resembles that of *A.* (*S.*) *dendrophilus*, indeed we were unable to find any points of constant difference. From the pupa of *A.* (*S.*) *luteocephalus*, however, it differs in several particulars, notably in the development of the fringe on the paddles.

*Habitat.*—Accra, in a rot-hole in a flamboyant tree (*Poinciana regia*) 24.xii.1918; Nsawam, in a rot-hole of a silk-cotton tree, 26.iii.1920, and in another tree of unknown species, 14.iv.1920.

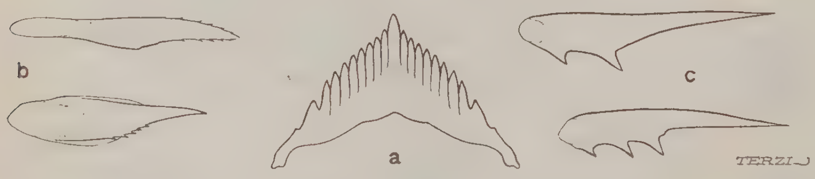


Fig. 18. Larva of *Aëdes apicoargenteus*, Theo.: *a*, mental plate; *b*, comb scales; *c*, pecten scales.

**Aëdes (Stegomyia) dendrophilus,** Edw.

Larva.—The larva has a darkly-coloured head and siphon tube; length about 5 mm. The following description is based on the examination of two mature larvae and six larval pelts.

*Head* strongly chitinised, dark-coloured; in mature specimens length and greatest breadth about equal (0·7 mm.). Antennae dark, especially at the base, not covered with spicules, and bearing a single small hair in place of a tuft, length about 0·3 mm. Mid-frontal hairs single, long and slender. Eyes large and well-formed. Mental plate (fig. 19, *a*) rather short and broad, with a median tooth and nine to twelve smaller teeth on each side.

*Thorax* broad, about 1 mm. in mature specimens, moderately well clothed with hairs, spines not very highly developed.

*Abdomen* only moderately hairy, bearing numerous small single, double and triple hairs, and long double lateral hairs which are well developed, especially on the anterior segments. Comb composed of about ten spines set in a transverse row, the spines highly chitinised, sharply pointed—but the extreme tip frequently broken off—and with very small secondary barbs hardly visible, except with high powers of the microscope (fig. 19, *b*). The siphonal tuft is triple, the subsiphonal composed of five hairs, and the anal of triple hairs; all the hairs simple or very slightly pubescent. Siphon very dark-coloured, length nearly three times the basal width (about 0·7 mm. to 0·25 mm.). The pecten extends half the length of the siphon or further and is composed of about eleven to thirteen spines, the last one or two sometimes outlying; the spines are sharply pointed and with very small secondary barbs hardly visible without the aid of high objectives of the microscope (fig. 19, *c*). The siphon tuft lies just beyond the last spine of the pecten and is composed of a single or double stout hair; when there are outlying pecten spines the tuft is proximal to them and thus appears to lie in the line of the pecten. Anal segment short. Papillae long and broad, with rounded ends; all four equal in length and longer than the anal segment. Beard poorly developed. Dorsal hairs well developed, two or three above and one below on each side. On each side of the anal segment, near the middle of its posterior margin, is a long single or more usually double hair.

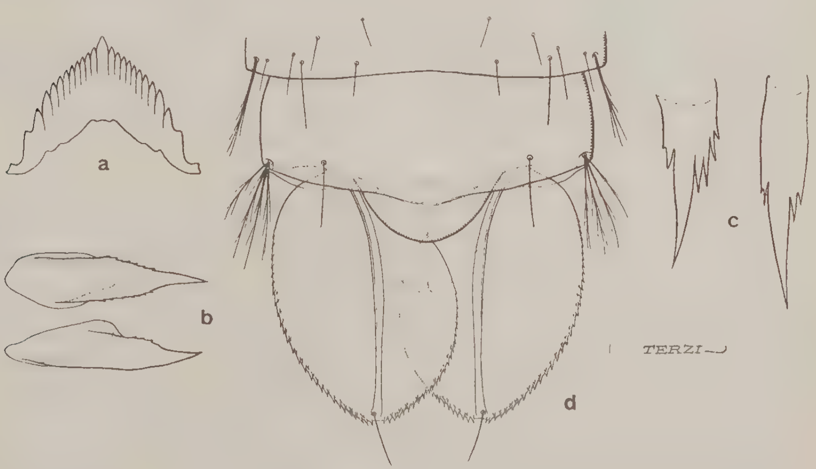


Fig. 19. *Aëdes dendrophilus*, Edw.: *a*, mental plate of larva; *b*, comb scales; *c*, pecten scales; *d*, pupal paddles.

*Diagnosis.*—The larva resembles in some respects that of *A.* (*S.*) *luteocephalus*, but may be distinguished from it by the characters of the scales of the pecten. It may be noted in this connection with regard to *A.* (*S.*) *luteocephalus* that the hook-like spines on the thorax are generally rather less well developed than those of *A.* (*S*). *argenteus* and rather better developed than those of *A.* (*S.*) *dendrophilus*; that the comb-scales when highly magnified are seen to be finely fringed; that the siphonal and subsiphonal tufts when similarly magnified are seen to be slightly subplumose and more so than those of *A.* (*S.*) *dendrophilus*; and that the hair on the siphon representing the tuft is sometimes divided, although usually single.

Pupa.—The pupa is of moderate size, measuring about 4 mm. to 5 mm. when extended, and is well chitinised. The following description is based on the examination of ten specimens. The paddles (fig. 19, *d*), which average about 0·7 mm. in length, are rather narrow, narrower than those of *A.* (*S.*) *argenteus*, and in both sexes are somewhat pointed at the distal extremity, the ratio of their length to their greatest breadth averaged 1·4 to 1. They are supported by a broad, highly chitinised, midrib, but there is little if any trace of an external buttress. The seta at the distal end of the midrib is usually single, occasionally double or bifid, it is long, average length about 115 $\mu$. The paddles bear a short fringe of somewhat denticulate processes. The chaetotaxy of the pupa is similar to that of *A.* (*S.*) *argenteus*. The lateral setae (A) at the posterior angles of segment viii are not very large tufts, which are somewhat variable; in the ten specimens examined they were composed of from two to eight setae, average four, which were sometimes simple, sometimes subplumose, sometimes branched. On segment vii these tufts are poorly developed and are generally represented by a single stout seta which is usually simple but may be subdivided into two or three branches and may be subplumose. The lateral setae on the sixth and more anterior segments are quite small, single and simple. The other setae of the pupa do not call for special mention as they are apparently similar to those of *A.* (*S.*) *argenteus*; they are, however, rather small and usually single.

*Diagnosis.*—The most characteristic feature of the pupa is the shape of the paddle, which distinguishes it from the other species, except *A.* (*S.*) *apicoargenteus*, that we have examined. It should, however, be noted that the pupal paddles of the male of *A.* (*S.*) *luteocephalus* are of the same shape, but they have a well-developed fringe, which is lacking in *A.* (*S.*) *dendrophilus*.

*Habitat.*—Aburi, in a banana stump, 6.vi.1920, and in cut bamboo, 26.v.1920, and 21.xi.1920; Dodowah, in a rot-hole of a mango tree, 17.xii.1921; Nsawam, in a rot-hole of a silk-cotton tree, 16.iii.1920 and 14.iv.1920; Oblogo, in a rot-hole of a tree, species unknown, 17.iv.1920.

**Culex annulioris,** Theo.

Larva.—The larva of this mosquito has been figured by Edwards (Bull. Ent. Res. iii, p. 384) and included in his key to the larvae of African Culicinae; it is therefore unnecessary for us to do more than mention a few additional characters.

The tuft on the antenna is situated just before the middle of the shaft, and is composed of pubescent hairs. The mental plate is similar to that of *C. bitaeniorhynchus*. The lateral abdominal hairs are subplumose, triple on the first four segments, double thereafter. The comb in our specimens is composed of five teeth, four arranged in a row, and one, in the middle, behind them. The siphon is long, variable in size, but about three-quarters the length of the abdomen, and from ten to thirteen times as long as its basal diameter; it bears a pecten of about six (five to seven) slender spines and several small tufts of hairs (three widely separated ventral tufts and a pair of subapical tufts). The anal segment is rather long and narrow and bears a moderately well-developed beard. The dorsal hairs on the anal segment are three or four above and one below on each side. The anal papillae are long, slightly longer than the anal segment, subequal, and bluntly pointed at their extremities.

*Diagnosis.*—This larva resembles that of *C. bitaeniorhynchus* but may be distinguished from it by the number of pecten spines, which is about six instead of only three.

Pupa.—The pupa is large, and has infuscated paddles. Only a single pelt was examined.

*Cephalothorax.* The respiratory trumpets (fig. 20, *a*) are long and rather narrow, and in the living pupa are directed forwards; they are rather pointed at their tips, have not very wide openings, and are infuscated at the distal end and over a patch

a short distance above the base. They are about 1·1 mm. long, and the ratio of the length of the meatus to the total length is about 1 to 1·3. The cephalothoracic setae are mostly small and inconspicuous, but the internal postero-thoracic seta is a rather conspicuous tuft of about six subplumose hairs.

*Abdomen.* The paddles are infuscated and very broad; length about 1·0 mm., greatest breadth about 0·85 mm. The midrib and external buttress are moderately well developed, the latter extending more than half the length of the paddles. The infuscation is most marked at the distal end and to the inner side of the midrib. The hairs at the end of the midrib are two, both very small (25 $\mu$ to 30 $\mu$), but the one stouter than the other and subdivided at its end. There is no fringe, but the external buttress bears a few minute denticules.

The abdominal setae are generally similar to those of *Culex bitaeniorhynchus*. The lateral setae on segment viii are small tufts, about one-quarter the length of the paddle, composed of five stout, subplumose hairs: on segment vii similar tufts of three hairs; on segments vi and v long (0·4 mm.), stout, single setae; and on segment iv reduced to shorter, delicate, single setae. The sublateral setae on the dorsum on segments vi and v are long, strong, double setae reaching right across the succeeding segment; on segment vii single, more delicate and smaller, reaching only about half-way across the eighth segment; on segment iv tufts of three long hairs. The submedian setae increase in size from behind forwards; on segments vii and vi they are single hairs; on segments v, iv and iii tufts of two to three, four to five, and about seven hairs respectively. The dendritic tufts on segment i are well developed. The other abdominal setae do not call for special mention.

*Diagnosis.*—This pupa resembles closely that of *C. bitaeniorhynchus*, but may be distinguished from it, apparently, by the narrower opening of the respiratory trumpets (fig. 20). Further material is required to confirm any small differences there may be in the cephalothoracic and abdominal setae.

*Habitat.*—Accra, 26.ix.1921, found in pools on the western side of Korley Gona.

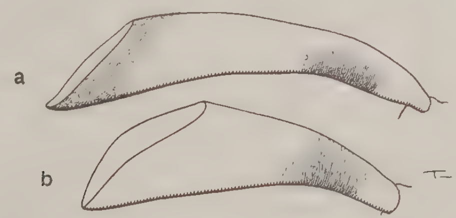


Fig. 20. Pupal trumpets of: *a*, *Culex annulioris*, Theo.; *b*, *C. bitaeniorhynchus*, Theo.

**Culex ingrami,** Edw.

LARVA.—The larva of this mosquito has already been described (Bull. Ent. Res. vii, pp. 11–12).

PUPA.—The pupa, of which only a single specimen was examined, is rather feebly chitinised and has long slender respiratory trumpets (fig. 21, *a*) and long sublateral setae on the dorsal aspect of the fifth and sixth abdominal segments.

*Cephalothorax.* The respiratory trumpets are long and slender tubes with an infuscated band a little above their bases, and with narrow apertures. Their length is about 0·6 mm., their width in the middle about 95 $\mu$, and the length of the apertures (pinna) about 93 $\mu$; the ratio of the length of the meatus to the total length is nearly

1 to 1·2. The cephalothoracic setae are small and call for no special mention; but the postero-thoracic setae are moderately well developed, the internal being composed of about half a dozen hairs, and the other two apparently each of two hairs.

*Abdomen.* The paddles are of moderate size and are relatively broad; length about 0·7 mm., greatest breadth about 0·5 mm. The external buttress is poorly developed and denticulated. The midrib is well developed. The hairs at the distal end of the midrib are two, single, both very small and measuring about 50 $\mu$ and 25 $\mu$ in length respectively. There is no fringe.

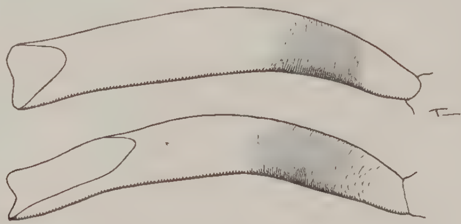


Fig. 21. Pupal trumpets of: *a*, *Culex ingrami*, Edw.; *b*, *C. decens*, Theo.

The abdominal setae are similar to those of *C. decens*. The lateral setae on segment viii are tufts, rather more than one-quarter the length of the paddles, composed of eight or nine rather stout subplumose hairs, some of which are branched; on segment vii similar but rather smaller tufts of five hairs, which are also subplumose and usually branched; on segments iii to vi delicate tufts of five simple slender hairs. The sublateral dorsal setae on segments v and vi are long, double (but one branch subdivided on one side of segment v) hairs reaching a little beyond the posterior margin of the following segment; on segment vii short single or double hairs; and on segment iv long quadruple hairs reaching right across the following segment. The submedian setae are tufts increasing in size from small tufts of four hairs on segment vii to large tufts of about nine hairs on segment iv and of about fifteen hairs on segment iii. On segment viii the seta P at the root of the paddle is slender and double. On segment ii the seta A′ is long, as in *C. decens*. The dendritic tufts on segment i are well developed. The other abdominal setae do not call for special mention.

*Diagnosis.*—This pupa closely resembles that of *C. decens*, but so far as can be judged from a single specimen, differs from it in that the respiratory trumpets have smaller apertures (fig. 21) and the lateral setae on segments iii to v have rather more hairs. It resembles also the pupae of *C. guiarti* and *C. grahami*, the most notable difference being, perhaps, in the length of the sublateral setae on segments v and vi, which are rather longer than one abdominal segment, but not as long (or nearly as long) as two, as they are in these two species.

*Habitat.*—Near Dodowah, 14.i.1922, in a small pool in a borrow-pit close to a native village.

**Culex grahami,** Theo.

Larva.—The larva of this mosquito, which was described by Wesché (Bull. Ent. Res. i, p. 46) under the name *C. pullatus*, Graham, is re-described here in rather greater detail in order that a comparison may be made with the larva of *C. guiarti*, Blanch. The larva is about 4·5 mm. in length when fully grown, and has a very long siphon (over 3 mm.). In water it rests with the siphon nearly vertical and the body almost at a right angle to it, and with the head bent downwards.

*Head* large but not highly chitinised; length about 0·9 mm., greatest breadth about 1·3 mm. Antenna slightly curved and bearing at about two-thirds of its length a large tuft of plumose hairs. The portion of the shaft distal to the tuft is very dark-coloured and highly chitinised. There are numerous spicules on the shaft, those on the pale basal portion slender, those on the dark apical portion stouter. At the end of the antenna are three long, stout, dark hairs which are simple, and not pubescent as they are in *C. guiarti*, a short spine-like dark hair with smaller spines at its base, and a small, less highly chitinised cylindrical organ, which apparently is the "spine" that Wesché notes as being "very liable to injury." The post-antennal hairs (to use the terms employed by Lang) are well-developed tufts of plumose hairs, the outer composed of about a dozen hairs, the longest of which extend beyond the middle of the antenna, the middle composed of two or three and the inner of three to five hairs. In *C. guiarti* the middle and inner tufts are each composed of two hairs. The mental plate has a large, rather bluntly-pointed central tooth, with a closely applied small tooth and more externally five more widely separated teeth on each side.

*Thorax* not so wide as the head; it has well developed lateral tufts of plumose or subplumose hairs and long hairs projecting over the head.

*Abdomen.* The lateral abdominal hairs appear to be triple on all the segments but are strongly developed on the first two segments only. Curious dendritic tufts, most strongly developed on the posterior segments, are also present. The siphonal, subsiphonal and anal tufts are well developed, the hairs composing the two first being plumose, those composing the last apparently pubescent or simple. The comb is made up of about fourteen to twenty pointed and fringed scales arranged in an irregular patch. The siphon is about twelve to fourteen times as long as the diameter of its base, tapering slightly in the basal quarter but thereafter almost uniformly cylindrical. The pecten is composed of six to nine simple spines confined to the basal seventh of the siphon. Distal to the pecten are several pairs of very delicate small hair-tufts, each composed of two or three hairs. Anal segment slightly longer than broad with papillae equal, long, slender, and pointed at their extremities, exceeding the anal segment slightly in length. The beard is moderately well developed, its constituent hairs rather longer than the papillae. Dorsal hairs at the posterior margin of the anal segment four to six above and a single longer hair below on each side.

*Diagnosis.*—This larva bears a general resemblance to that of *C. guiarti*, but may be distinguished from it by numerous characters, such as those of the post-antennal hairs on the head, the number of spines in the comb and pecten and the dorsal hairs on the anal segment. These differences are notable and appear to indicate that the two mosquitos are distinct and not merely varieties of a single species.

PUPA.—The pupa is greenish in colour, and resembles that of *C. guiarti*, but is more highly chitinised.

*Cephalothorax.* The respiratory trumpets (fig. 22, *a*) are long and slender, their basal halves dark and highly chitinised, and their distal ends with narrow apertures. Their length is about 0·85 mm. and the ratio of the length of the meatus to the total length of the trumpet is about 1 to 1·1. The cephalothoracic setae are mostly inconspicuous and call for no special comment. The postero-thoracic setae, however, are small, each composed of two hairs, whereas in *C. guiarti* apparently the internal one is composed of about five and the external of three hairs.

*Abdomen* (fig. 22, *b*). The paddles are of moderate size, length about 0·8 mm., greatest breadth about 0·6 mm. The external buttress is rather slender and is denticulated, the midrib being somewhat more substantial. There is no fringe. The hairs at the distal extremity of the midrib are very small. The abdominal setae are similar to those of *C. guiarti*. The lateral setae on segment viii are small tufts, about one-quarter to one-third of the length of the paddles, composed of seven to nine

hairs; on segment vii are similar tufts of five or six hairs; on segments iii to vi are delicate tufts composed of three to five hairs. The sublateral dorsal setae on segments v and vi are long double hairs reaching nearly across the two following segments; on segment vii is a much shorter hair; and on segment iv a long, usually triple hair (quadruple in the specimen figured) reaching across the following segment and often half of the one beyond that. The submedian setae are tufts increasing in size from a small tuft of two or three hairs on segment vii to a larger tuft on segments iii and iv composed of ten to sixteen and ten or eleven hairs respectively. On segment viii the seta (P) at the root of the paddle is slender and double. On segment ii the seta (A′) is, as in *C. guiarti*, very long and single. The dendritic tuft on segment i is well developed.

*Diagnosis.*—This pupa resembles closely that of *C. guiarti*, but appears to be more robust and is generally more heavily chitinised. It may be distinguished from it, to mention only one character, by the sublateral setae on segment iv, which are long, usually triple hairs reaching across the following segment and not shorter tufts of about five hairs.

*Habitat.*—Accra, 26.ix.1921, a single larva collected in a pool on the western side of Korley Gona; Ofako, a village about nine miles north of Accra, on the Nsawam road, 5.vi.1922, larvae found in a pool in a swamp; in the same pool were also larvae of *Anopheles marshalli*.

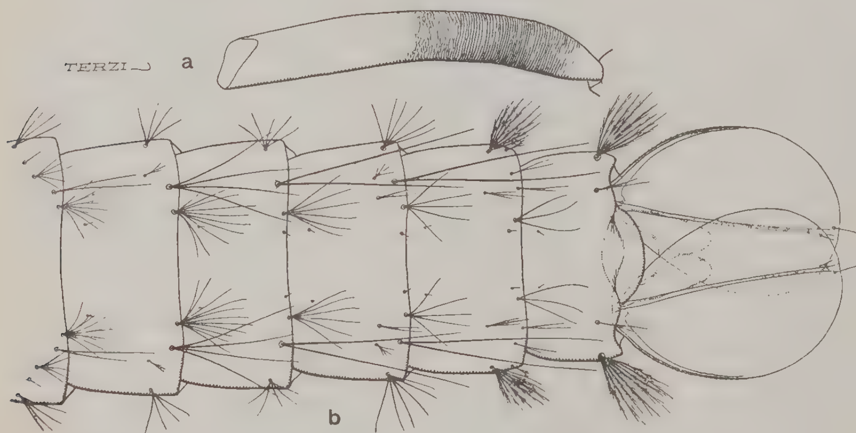


Fig. 22. Pupa of *Culex grahami*, Theo.: *a*, trumpet; *b*, dorsal view of abdomen.

**Culex (Culiciomyia) macfiei,** Edw.

LARVA.—Length about 4 mm. when fully grown; siphon long, about 1·3 mm., and dark brown.

*Head* (fig. 23) large, almost as broad as the thorax, not very highly chitinised, length about 0·8 mm., greatest breadth about 0·9 mm. Eyes large, situated at the broadest part of the head. Antennae about 0·4 mm. long, slightly curved, a little infuscated, especially at the ends, spiculated over the basal two-thirds, and bearing a well-developed tuft of subplumose hairs at about three-quarters of the length from the base. The pre-antennal hair of Lang is a small, simple, single hair, the outer post-antennal a well developed tuft of about eight subplumose hairs, the mid post-antennal a long, double, subplumose hair, and the inner post-antennal a similar long hair, which is triple. Mental plate (fig. 23, *a*) rather small, with a large, pointed, central tooth and about nine smaller teeth on each side of it.

*Thorax* broad; length about 0·8 mm., greatest breadth about 1 mm. The setae on the anterior border are long, longer than the head. The lateral tufts are well developed.

*Abdomen* with long lateral tufts on the first two segments, and thereafter shorter, double, dorso-lateral hairs. Comb (fig. 23) composed of about thirty-six small, dark, fringed spines arranged in a triangular patch. The siphonal tuft small, composed of about four rather stout subplumose hairs; the subsiphonal longer, composed of about eight subplumose hairs; the anal small, double, pubescent. The siphon (fig. 23) is very dark brown, long, length about eight times the basal diameter, tapering only slightly, and bearing on its distal two-thirds three or four pairs of tufts composed of three or four rather long pubescent hairs. Pecten composed of about

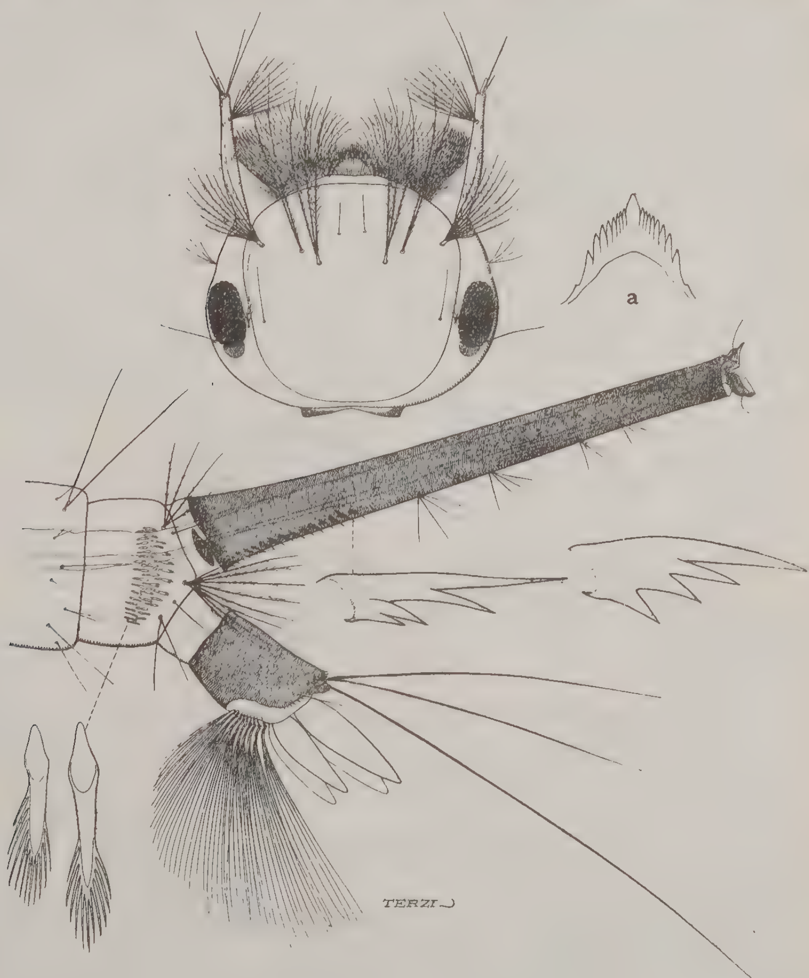


Fig. 23. Larva of *Culex macfiei*, Edw., head and terminal segments of abdomen: *a*, mental plate.

fourteen to sixteen pointed, barbed spines, arranged in a row which reaches about one-third of the length of the siphon from its base. Anal segment longer than broad, the chitinised part very dark brown, covered by short transverse rows of spicules, the posterior margin bearing on each side a few small spines and a small single hair. Beard well developed. Dorsal setae long; two above and one below on each side. Anal papillae short, pointed, the dorsal pair longer than the ventral.

*Diagnosis.*—According to Edwards's key (Bull. Ent. Res. iii, p. 381) this larva has to be distinguished from that of *Culex decens*, Theo.; this is readily done by the tufts of hairs on the siphon, to mention only a single character.

PUPA.—The pupa is small, length about 4 mm. when extended, and not very highly chitinised.

*Cephalothorax* slightly infuscated dorsally. Respiratory trumpets (fig. 24, *a*) dark brown, relatively long and narrow, with small apertures; length about 0·5 mm., ratio of length of the meatus to the total length about 1 to 1·2. Setae well developed, especially the post-ocular setae; the lower anterior seta of the antero-thoracic group not very large, dorsal setae double or triple.

*Abdomen* (fig. 24, *b*). Paddles delicate, more or less oval; length about 0·65 mm., greatest breadth about 0·4 mm., ratio 1·6 to 1. The midrib and external buttress are not strongly developed; and the terminal seta (fig. 24, *c*) (which appears to be single) is small, about one-tenth the length of the paddle, divided at its end.

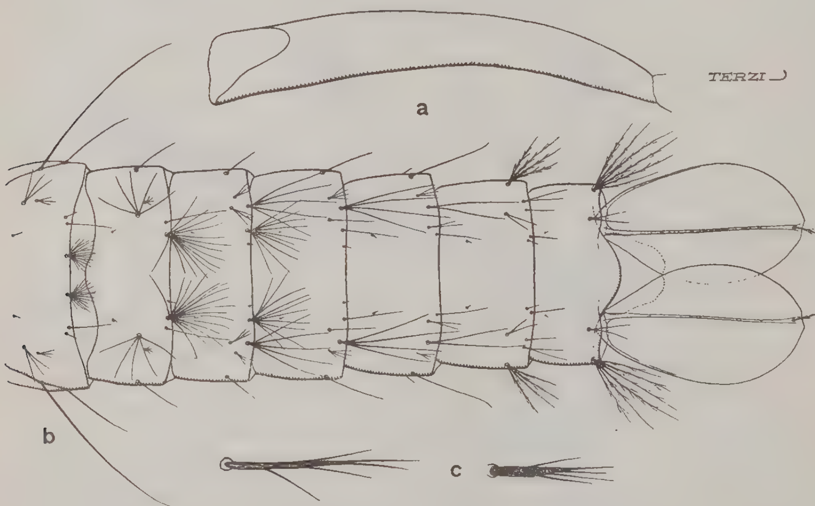


Fig. 24. Pupa of *Culex macfiei*, Edw.: *a*, trumpet; *b*, dorsal view of abdomen; *c*, terminal seta of paddle.

The dorsal abdominal setae are moderately well developed. The lateral setae (A) on segment viii are tufts about half the length of the paddles composed of about seven subplumose hairs, which are often branched; on segment vii similar but smaller tufts of about three or four hairs; and on segments iii to vi long single hairs. The sublateral setae (B) on segment vii are small, delicate, single or double, not reaching across the eighth segment; on segment vi stouter, longer, double setae; and on segments iv to v long tufts of about three to five hairs reaching back beyond the posterior margin of the following segment; these setae are slightly subplumose or pubescent. The submedian setae (C) on segments v to vii are delicate, single or

double hairs reaching about half across the following segment, on segments iii to iv larger, delicate tufts, the former composed of about fifteen to seventeen and the latter of about seven to nine slightly subplumose hairs. The dendritic tufts on segment i are large and greatly branched; those on segment ii are smaller but relatively well developed.

*Diagnosis.*—This pupa is quite unlike that of *C. decens*, Theo., and may readily be distinguished by the characters of the chief abdominal setae. As has already been mentioned the lower seta of the antero-thoracic group on the cephalothorax is not exceptionally large, as it is in *Culiciomyia nebulosa*, Theo. The adult of this species, which is new to science, is described above (p. 399).

*Habitat.*—Ofako, a village about nine miles from Accra, on the Nsawam road, v.1922; larvae collected from a rot-hole in a tree in dense bush; from the same rot-hole were also obtained larvae of *Toxorhynchites brevipalpis*, Theo., *Aëdes (O). apicoannulatus*, Edw., and of *Aëdes (Finlaya) longipalpis*, Grünb.

**Culex (Micraëdes) inconspicuosus,** Theo.

LARVA.—The larva of this mosquito has not yet been identified.

PUPA.—The pupa is rather feebly chitinised; length when extended about 3 mm. Four pelts were examined.

*Cephalothorax.* The respiratory trumpets (fig. 25, *a*) are long and narrow, with a broad dark band a little proximal to the middle; length about 0·57 mm., middle breadth about 77 $\mu$; the opening is of moderate size, the ratio of the length of the meatus to the total length of the trumpet being about 1 to 1·3. The setae on the cephalothorax are small and not very highly chitinised. The dorsal setae are rather long tufts of two to four hairs. The postero-thoracic setae are moderately well-developed tufts, the inner of about four, the median two, and the external three hairs.

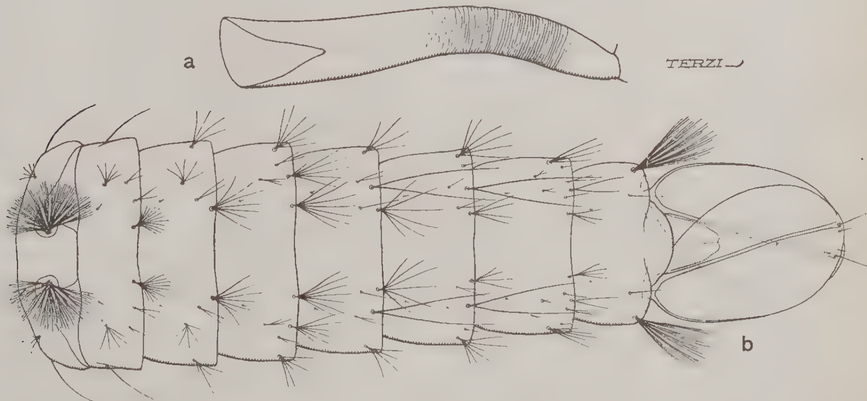


Fig. 25. Pupa of *Culex inconspicuosus*, Theo.: *a*, trumpet; *b*, dorsal view of abdomen.

*Abdomen* (fig. 25, *b*). The paddles are obovate; length about 0·6 mm., greatest breadth about 0·4 mm. The midrib is moderately well developed, and there is a narrow external buttress which appears to extend about half the length of the paddle. At the distal end of the midrib are two hairs, the one rather long, nearly one-fifth the length of the paddle, and the other quite short (about 30 $\mu$); these hairs are usually single, occasionally forked. There is no fringe.

The arrangement of the abdominal setae, except in the case of the following dorsal setae, does not call for special mention. The lateral setae on segments iii to vi are tufts of about five delicate hairs, on segment vii tufts of three or four stout branched setae, and on segment viii rather larger tufts of five or six similar setae. The lateral tufts on segment viii are about two-fifths the length of the paddles. The sublateral setae on segments v and vi are long double setae reaching further than the posterior margin of the following segment ; on segment vii they are single or double, shorter and smaller, not reaching quite across the eighth segment ; and on segment iv they are moderate-sized tufts of hairs. The submedian setae on segments iv to vii are tufts of hairs which are largest on the more anterior segments. The dendritic tufts on segment i are well developed and have about ten primary branches. On the posterior margin of segment ii, on each side of the middle line, are tufts similar to those of *Culex* ; these tufts are delicate, their stems rather narrow, and their branches very fine hairs.

*Diagnosis.*—The pupa in most respects resembles that of *Culex*, but apparently may be distinguished by the fact that one of the terminal setae on the paddle is long, nearly a fifth the length of the paddle.

*Habitat.*—Oblogo, 25.xii.1920, from pools in swampy ground.

# REPORT ON A TEST OF A METHOD OF ATTACKING *GLOSSINA* BY ARTIFICIAL BREEDING PLACES.

By G. D. Hale Carpenter, M.D., F.E.S.,
*Uganda Medical Service.*

In 1913 Major Austen asked me whether it would not be possible to reproduce artificially the conditions which tempt the female *Glossina palpalis* to deposit its larvae (Report of Departmental Committee of Colonial Office on Sleeping Sickness, June 1914. Questions 1420, 1421) I replied that I thought it would, and early in 1914, on my return to Uganda, commenced a preliminary experiment to test the possibility of reducing the numbers of *palpalis* by providing highly attractive artificial shelters under which larvae would be deposited in numbers, and where the pupae could be collected easily and regularly destroyed. These preliminary investigations were described in my Fifth Report on the bionomics of *palpalis* published in the Reports of the Royal Society's Sleeping Sickness Commission (No. xvii), and it was claimed that these results were sufficiently promising to make the method worth attention and further experimental trial. Before I went on long leave in 1919 I had arranged for such a trial to be carried out in my absence, but the experiment came to an end from causes beyond my control before a satisfactory result could be obtained either confirming or contradicting the claims made for the method.

It was not possible to initiate another test until February 1921, when I went out to the two islands of Bulago and Kimmi to supervise the construction of the shelters. These have been previously described, and each consists merely of a low sloping thatched roof built over suitable loose soil near the water at a part of the lake shore where fly was abundant and where the conditions existed that are known to be favourable to the pupae.

The islands of Kimmi and Bulago had been closely studied and the natural breeding grounds of *palpalis*, which is abundant, were all known. In December 1919 timed catches of *palpalis* at different parts of Kimmi gave an average estimate of 75 males caught per boy per hour, and for Bulago the average was 49.

The islands of Kimmi and Bulago lie about ten and seven miles respectively from the nearest point of the mainland, and about fifteen miles south-east of Entebbe. A map showing the relative sizes and positions of these and the neighbouring islands has already been published in this Bulletin (vol. x, p. 352).

The small island of Tavu served as a possible control in the event of the experiment having caused a reduction in numbers of the fly on Kimmi and Bulago; a catch made in December 1921, at the same time as on the other two islands, gave an average figure of forty-seven males per boy per hour. The two islands, Kimmi and Bulago, differ greatly; the former is flat and almost covered with forest and the jungle that grows up in neglected banana plantations; while the greater part of Bulago is open grass-land, save for the northern peninsula and a narrow strip of the northern and western coasts, which are forested, and the eastern and southern coasts are covered with thin bush. Two rounded hills rise out of the grass-land to a height of about 300 feet above the water.

The shelters were placed at various points round the islands. On Bulago a naturally attractive spot was found and left for comparison with the artificial shelters; it consisted of a large tree-trunk and mass of roots overhanging sand near the water. This was called locality No. 2, and was visited regularly. On Kimmi two such natural places were visited, one in the forest at a little distance from the east coast and one at the edge of the forest on the south coast; both were made by trees torn up by the wind, so that their roots formed a pent-house. These were Nos. 4 and 7. The shelters were made on a uniform plan but did not all face in the same direction. It was important to place them so that the slope of the roof faced

towards the direction whence rain might enter, and also so that as little sun as possible entered under the roof. Advantage was taken where possible of natural protection afforded by trees and bushes. The soil was either red or white coarse sand mixed with small stones.

Arrangements were made for a reliable native to visit each island at regular intervals of ten days, but on a few occasions the interval was unavoidably much longer. I think that ten days, or perhaps a fortnight, is the longest interval that should elapse ; during three weeks there is time for pupae to hatch out.

I went to the islands on 5th and 6th January 1922, and satisfied myself by watching the boy actually collecting that he did truly find the pupae in the shelters. As a matter of fact there was no other place on any of the neighbouring islands where he could have procured the same number of pupae in the time given him. A bonus was given of 20 cents. per hundred pupae in order to ensure a thorough search of the shelters.

Certain of the shelters proved to be much more attractive than others. On Bulago, Nos. 1, 5, 6, 8, and especially 5 and 6, were most attractive, and on Kimmi Nos. 2, 5 and 6, and especially 2, provided most pupae.

It is noteworthy that the natural breeding-places that were especially selected for comparison with the artificial breeding-places, as likely to provide most pupae, proved very inferior to the shelters (B.2, K.4 and 7). The largest number of pupae collected at any visit from one of the natural breeding-places was 116, whereas the largest number from a shelter was 551. On the other hand some of the shelters (B.3) were inferior to some of the natural places (see Table).

The number of pupae yielded by any one shelter showed great variation : thus No. 5 on Bulago yielded on 7th September, 126 ; on the 18th, 100 ; on the 26th, 33 ; on 7th October, 256. Again, No. 2 on Kimmi yielded 423 on 25th November ; 4 on 6th December ; 75 on 16th December. It is difficult to account for these sudden drops, but a possible explanation may be that for a short period there was an absence of a good supply of food in the neighbourhood of that particular shelter.

### *General Conclusions.*

A great amount of labour has been spent in plotting out the results together with records of temperature, rainfall, hours of sunshine and relative humidity, calculated from meteorological records kept at Entebbe. Unfortunately it was not possible to obtain meteorological records for the islands on which the experiment was being made, but they are sufficiently close to Entebbe for the data obtained to be useful.

The total yield for each period was divided by the number of days to get a daily average for the period, and daily averages of the meteorological data were obtained for comparison.

Study of the charts (not reproduced) shows no definite correlation between the pupae curve and any of the others ; although I had expected to find that the seasons of least humidity would be the seasons when most pupae were deposited.

Finally, I must reluctantly conclude that my hopes of the utility of this method as a means of destroying *Glossina palpalis* without any other measures at all, have not been justified. After very nearly a year there was no appreciable diminution in the number of pupae deposited.

The method, however, has proved its value as a means of readily obtaining large numbers of pupae for laboratory purposes. A batch was sent to the Zoological Society, and many arrived alive. Unfortunately a breakdown in the heating arrangements of the insect house on two very cold nights resulted in the death of those that had survived the voyage.

It seems probable that combined with destruction of the most favoured breeding-places this method might greatly help in reducing the numbers of the fly.

TABLE SHOWING NUMBERS OF PUPAE COLLECTED FROM EACH LOCALITY.

| Date of Collection. | | 1921 March. | | | April. | | | May. | | June. | | | July. | | | August. | | | September. | | | October. | | Nov. | | Dec. | | 1922 January. | | | Feb. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 16 | 29 | 11 | 21 | 29 | 13 | 24 | 1 | 12 | 24 | 6 | 14 | 24 | 8 | 16 | 27 | 7 | 18 | 26 | 7 | 19 | 15 | 24 | 5 | 15 | 5 | 16 | 28 | 10 |
| | *Shelter No.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bulago. | 1 | 14 | 99 | 98 | 125 | 160 | 34 | 71 | 18 | 58 | 146 | 80 | 71 | 113 | 303 | 132 | 102 | 55 | 75 | 118 | 18 | 31 | 30 | 28 | 128 | 92 | 28 | 37 | 45 | 36 | 49 |
| | 2 | 10 | 36 | 5 | 27 | 23 | 3 | 0 | 2 | 0 | 2 | 2 | 3 | 6 | 6 | 4 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 7 | 0 | 3 | 3 | 3 | 0 | 5 | 7 | 2 | 20 | 7 | 21 | 9 | 17 | 21 | 27 | 26 | 15 | 28 | 10 | 4 | 21 | 39 | 63 | 18 | 4 | 8 | 12 | 9 | 15 |
| | 4 | 13 | 5 | 12 | 7 | 8 | 5 | 13 | 2 | 9 | 28 | 17 | 2 | 28 | 11 | 115 | 57 | 27 | 9 | 17 | 6 | 29 | 28 | 24 | 116 | 34 | 2 | 54 | 39 | 44 | 17 |
| | 5 | 145 | 177 | 173 | 184 | 114 | 119 | 150 | 102 | 138 | 192 | 202 | 180 | 219 | 246 | 254 | 231 | 99 | 126 | 100 | 33 | 256 | 105 | 197 | 223 | 171 | 74 | 126 | 160 | 244 | 185 |
| | 6 | 356 | 307 | 405 | 465 | 242 | 55 | 84 | 37 | 34 | 8 | 162 | 135 | 91 | 272 | 114 | 165 | 45 | 179 | 164 | 136 | 83 | 250 | 309 | 177 | 480 | 274 | 551 | 501 | 502 | 194 |
| | 7 | 10 | 5 | 15 | 23 | 18 | 14 | 25 | 5 | 10 | 11 | 26 | 18 | 22 | 25 | 31 | 4 | 3 | 31 | 21 | 10 | 12 | 7 | 12 | 18 | 12 | 6 | 15 | 23 | 18 | 24 |
| | 8 | 266 | 194 | 133 | 171 | 142 | 66 | 76 | 83 | 23 | 51 | 66 | 67 | 40 | 60 | 86 | 80 | 92 | 113 | 163 | 76 | 122 | 219 | 84 | 174 | 233 | 78 | 104 | 82 | 75 | 74 |

| Date of Collection. | | March. | | | April. | | | May. | | June. | | | July. | | | August. | | | September. | | | October. | | Nov. | | Dec. | | January. | | | Feb. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 17 | 30 | 12 | 22 | 30 | 14 | 25 | 2 | 13 | 25 | 7 | 16 | 25 | 9 | 17 | 28 | 8 | 19 | 27 | 8 | 20 | 16 | 25 | 6 | 16 | 6 | 17 | 29 | 11 |
| | *Shelter No.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Kimmi. | 1 | 27 | 64 | 170 | 143 | 14 | 23 | 65 | 33 | 60 | 18 | 81 | 84 | 67 | 63 | 54 | 50 | 37 | 78 | 91 | 63 | 125 | 45 | 39 | 7 | 9 | 26 | 7 | 44 | 9 | 35 |
| | 2 | 180 | 304 | 252 | 261 | 306 | 310 | 236 | 110 | 106 | 343 | 213 | 154 | 343 | 214 | 261 | 256 | 162 | 344 | 396 | 156 | 348 | 166 | 246 | 423 | 4 | 75 | 60 | 139 | 12 | 64 |
| | 3 | 91 | 80 | 40 | 263 | 80 | 62 | 24 | 23 | 8 | 6 | 10 | 3 | 42 | 55 | 66 | 14 | 69 | 131 | 150 | 72 | 38 | 50 | 25 | 155 | 64 | 31 | 120 | 43 | 43 | 31 |
| | 4 | 48 | 3 | 116 | 39 | 70 | 1 | 2 | 0 | 0 | 2 | 5 | 1 | 8 | 12 | 32 | 9 | 9 | 1 | 84 | 54 | 36 | 22 | 63 | 36 | 19 | 7 | 0 | 24 | 12 | 8 |
| | 5 | 79 | 99 | 21 | 87 | 0 | 64 | 73 | 32 | 26 | 38 | 42 | 29 | 51 | 80 | 19 | 4 | 13 | 12 | 31 | 32 | 5 | 88 | 48 | 73 | 39 | 60 | 121 | 84 | 80 | 93 |
| | 6 | 229 | 116 | 72 | 110 | 10 | 25 | 8 | 33 | 9 | 2 | 11 | 5 | 12 | 16 | 18 | 48 | 54 | 66 | 54 | 31 | 185 | 103 | 87 | 213 | 3 | 178 | 138 | 121 | 4 | 152 |
| | 7 | 14 | 8 | 6 | 15 | 1 | 7 | 8 | 6 | 3 | 1 | 1 | 2 | 4 | 24 | 102 | 2 | 0 | 9 | 1 | 0 | 6 | 19 | 23 | 48 | 24 | 12 | 0 | 27 | 109 | 26 |

# A NEW SPECIES OF LYGUS INFESTING POTATOES IN JAVA (RHYNCHOTA, CAPSIDAE).

By W. E. China, B.A.

**Lygus solani,** sp. n.

*Head* 0·83 mm. long, shiny orange-yellow, with the clypeus and the adjoining portion of the frons shiny black. Eyes black, prominent, extending laterally beyond the anterior lateral margins of the pronotum. Rostrum brownish black, extending to, but not surpassing, the posterior coxae ; lengths of the joints : first 0·53 mm., second 0·76 mm., third 0·4 mm., and fourth 0·6 mm. *Antennae* brownish black, the third and fourth joints somewhat paler ; first joint slightly incrassated, length 0·83 mm., second 2·0 mm., third 1·83 mm., fourth 1 mm. *Pronotum* shiny orange-yellow, posteriorly somewhat suffused with dark brown ; length in middle 1·4 mm., breadth at anterior margin 0·8 mm., at posterior margin 2·0 mm. ; sides straight, posterior margin moderately convex. *Scutellum* shiny black, finely rugosely punctate and regularly covered with pale depressed hairs ; length in the middle 1·3 mm. *Corium* and cuneus similar in colour and pilosity to the scutellum ; membrane dark smoky brown, veins shiny black, passing the apex of the abdomen. *Sternum* : mesostethium and metastethium black, the metastethial orifices and the surrounding areas very pale yellow : undersides of abdomen shiny black, covered with very fine pale hairs. *Legs* : coxae blackish brown ; femora dirty orange-yellow, suffused at base and apex with brown ; tibiae dark brown, armed with fine black spines ; tarsi black, strongly pilose.

*Length*, including membrane, 6·5 mm.

Java : Dapet di pohon, Kentang, Lembang, 3 ♂♂, 10.viii.1922 (*P. van der Goot*).

*Type* in the British Museum.

Infesting the leaves and young shoots of potato plants.

# THE LARVA AND PUPA OF *ORTHOPODOMYIA ARBORICOLLIS*, D'EMMEREZ DE CHARMOY, 1908.

By Malcolm E. MacGregor,
*Entomologist, Wellcome Bureau of Scientific Research, Director, Malaria Research Laboratory, Réduit, Mauritius,*

and S. Gébert,
*Assistant.*

(Plate XXIII.)

*Orthopodomyia arboricollis* was described under the name of *Culex arboricollis* by d'Emmerez de Charmoy, from adults reared by him from larvae that were found by Sir Ronald Ross, K.C.B., F.R.S., in a tree-hole at Vacoas. Mr. d'Emmerez tells us that these adults were the only ones he has seen in his long experience in Mauritius, and the species so far is recorded from this island only. Mr. F. W. Edwards, after examination of the types in the collections at the Liverpool School of Tropical Medicine, has recently correctly assigned the insect to the genus *Orthopodomyia*.

Soon after opening the laboratory at Réduit a tree-hole was discovered near by containing very large numbers of the larvae of *Aëdes albopictus*. About 100 larvae from this tree-hole were brought to the laboratory in order to get good specimens for our collections. Before they were set aside to develop, the larvae were looked over with the naked eye and were judged to be all of one species, *Aëdes albopictus*, but some days later when adults had begun to emerge we were surprised to discover among them a particularly striking and beautiful male mosquito. It was at once recognised as *Orthopodomyia arboricollis*.

## Description of the Adult Mosquito.

The mosquito is quite remarkable, as it is a very large and beautifully ornamented Culicine with the wings spotted and banded so that they resemble the wings of an Anopheline, even to the dark and light bands on the costa.

d'Emmerez's description of the ♂ and ♀, which we have found excellent, is as follows :—

"♂.—*Head* : eyes greenish ; occiput yellowish, with long, white and yellow, curved scales ; the yellow scales are placed closely in the line separating the eyes. *Antennae* bear long hairs which are pale yellowish apically, and greyish-black basally ; the segments of the basal half furnished with very long, narrow curved scales ; apical segment with a few short hairs ; the basal segment with short, flat white scales. *Palpi* with four segments, as long as the proboscis, with narrow white bands at the base and apex of the 2nd, 3rd, and 4th segments ; white scales are disseminated all over the segments. *Proboscis* black, with the apex paler and a yellowish band in the middle. *Thorax* black, covered sparsely with long, narrow curved, white and golden scales, and long black hair-like scales ; those portions of the thorax which are not covered with scales form velvet-black spots. Scutellum bordered with flat whitish scales, and dark hair-like scales ; metanotum nude, black. *Abdomen* velvety-black, with whitish basal bands ; apical segment with a few whitish scales at apex ; all segments with long yellowish marginal hairs. *Legs* black, with more or less loosely scattered yellowish scales ; the articulations of the femora and tibiae are basally and apically banded ; the tarsi are black without any coloured scales ; metatarsi of the front legs are basally banded ; the other tarsal segments are black ; in the mid-leg the metatarsi and the first tarsal segments are basally banded ; in the hind legs the metatarsi are basally banded with yellowish scales, and apically banded with white scales ; all the remaining segments are basally and apically banded with white scales. *Wings* spotted ; the black spots on the costa extend to the auxiliary vein ;

they are seven in number and are situated as follows: two small basal ones, the second a little larger than the first, the third one having a white dot in its middle, the fourth and fifth ones united on the auxiliary vein by black scales, the sixth placed obliquely, the seventh near the apex; the other veins are irregularly spotted with white scales, the last vein (costa) which bears the black fringe is regularly spotted white and black on its basal half.

"The underside of the body bears the following markings:—*Pleura* densely covered with imbricated, flat, whitish scales; the *trochanters, coxae,* and the base of the *femora* are covered with white scales; the ventral segments of the *abdomen* are spotted basally with white scales, and apically with a well-defined, narrow white line.

"♀.—*Proboscis* black, with a few scattered white scales, and a white band just below the first anterior third. *Palpi* longer than the half of the proboscis, with a few scattered white scales and white bands; the apical segment bears two moderately long hairs. *Occiput*: the fore part of the occiput is covered with long, narrow, curved white scales; the hind portion with yellow, upright forked scales; the anterior lateral portions with black, upright forked scales. *Scutellum* with a median and two lateral tufts of long black hairs, and a few long, flat, curved white scales. *Thorax* and *pleura* as in the male. *Halteres* yellowish, with small white scales."

d'Emmerez adds: "The larvae of this species were found by Professor Ronald Ross in the holes of trees at Vacoas; and although the larval habitat was situate near dwellings no adults were seen in houses or verandahs. This well-marked species is apparently uncommon. . . ."

d'Emmerez's description of the adults is so good that we are only able to draw attention to the following additional characters:—

♂.—*Antennae*: hairs set on the dorsal and ventral aspects of the segments only and not arranged in whorls. *Palpi*: 4th segment very short and carrying a few moderately long hairs. *Legs*: 2nd tarsal segments of the middle legs often with a few white scales basally.

♂ and ♀.—*Legs*: hind legs abnormally and very conspicuously long, trailing behind the insect and lying parallel to each other with all the tarsal joints in contact with the surface on which the insect rests, instead of being curved upwards and raised freely in the air, as is usual in mosquitos.

### Observations on the Larva.

Until now the larva has remained unknown. We have found that the larva of this species, notwithstanding what d'Emmerez said in 1908, is exceedingly common, frequenting a great variety of tree-holes, and is widely distributed over the island. In some localities it is almost the commonest of the Mauritian tree-hole breeding mosquitos.

Apparently it hibernates as a larva, as we have been able to watch its slow development during the winter months in tree-holes that have been advantageously situated near the laboratory. Larvae taken from these tree-holes and kept under observation in the laboratory as controls have shown a parallel slow development—the temperature of the laboratory and that out of doors being practically the same. Towards the end of winter both the larvae in the tree-holes and those under observation indoors finally pupated.

The types of tree-hole water in which this species have been found have varied considerably. Clear tree-hole water, constantly refreshed by rain water from frequent showers, has seemed as favourable as stale dark sherry-coloured water from a large deep hole in a mango tree. The only difference noted being that in the clear tree-hole water larvae of *Aëdes albopictus* were often to be found in association, whereas in the dark sherry-coloured water of the mango tree enormous numbers of *O. arboricollis* larvae were alone found.

Larvae of the genus *Orthopodomyia* at the fourth instar have been characterised among other features as being of a reddish colour. This we found to be true for some *arboricollis* larvae—particularly in the third instar, but often those at the fourth instar were either practically colourless or as frequently blue-grey or even sky-blue. Another generic character of *Orthopodomyia* is the development at the fourth instar of chitinous plates on the 6th–8th abdominal segments. In this character also many of our larvae failed ; some of the larvae developing plates on the 6th, 7th, and 8th abdominal segments ; others developing any one, or combination of two, of the plates only ; while still others failed to develop any sign of a plate, and yet all pupated and emerged as perfectly normal adults with no apparent individual differences. The chitinous abdominal plates are clearly, in *arboricollis* at least, an exceedingly variable character.

Nor is this the only character in which the larvae of *arboricollis* show astonishing variation. In those collected from the mango tree-hole we noticed with the naked eye that there seemed to be present two such easily recognisable types that we felt almost certain two distinct species were associated. The one type had short, straight antennae, with slender frontal plumes, while the other had long, inwardly curved antennae and dense frontal plumes (Plate xxiii, figs. 2, 3).

When the larvae were examined carefully under the microscope, it was discovered that from one extreme to the other there were individuals presenting every intermediate variation. The larvae were separated into different tubes so that the variation in the frontal hairs would form a progressive series from the simplest type to the most densely plumose type. This was done with the object of demonstrating the points at which possible variations in the adults would appear. Every larva in the series, showing also all stages of abdominal-plate development, pupated and emerged successfully, but prolonged microscopical comparison failed to show a single distinction in the adults, either male or female. The whole of this series has been mounted and preserved.

The larvae to the naked eye are unusually hairy, and this condition gives to the thorax a characteristic appearance of being greatly widened. The larvae swim normally with a slow action of the abdomen, but when disturbed they are capable of rapid movement, diving to the bottom and remaining submerged for long periods. The specific gravity of the larvae is very nearly the same as that of water, and the larvae may often be seen in stable equilibrium at different depths in the water.

## Descriptions of the Early Stages.

*Larva in the Fourth Instar.*

*Antennae* of two forms : (1) straight and short, or (2) longer, curving downwards and inwards towards the apex (Plate xxiii, figs. 2, 3) ; both forms yellow in colour, with a small plume situated at a point about one-third from the base. *Frontal hairs* : eight frontal hairs carried on the anterior periphery of the head between the antennae. The plumes are exceedingly variable, sometimes being dense, with widely spreading branches, the tips of which curve gracefully upwards ; or these plumes only represented by simple, bifurcated, or sparsely branched hairs (Plate xxiii, figs. 2, 3). All intermediate variations between the two extremes occur, often in larvae from the same breeding-place. The pair of plumes nearest the middle line of the head are much smaller, and are placed a little in front of the others. Situated below each eye is a large downwardly directed plume. *Eyes* small and spherical. *Head* sub-globular, transparent, and from a point at the base of the antennae on the dorsal surface a dark line extends backwards enclosing the occipital area in the form of an open **V**. Between the arms of the **V** at about the centre of the head often an oval brown mark occurs. A few scattered simple hairs are present at other points on the head. *Thorax* ornamented at the sides with numerous long hairs bunched together. Dorsal surface ornamented with stellate spine hairs like those of *Finlaya geniculata*, and a few long simple hairs. Number of hairs in stellate spine very variable. *Abdomen* (Plate xxiii, figs. 1, 4) ornamented with stellate spine hairs laterally and dorsally,

but on the lateral aspects long single hairs also occur. Frequently chitinous plates are present on the 6th, 7th, and 8th abdominal and anal segments. These plates are, however, exceedingly variable, and may be absent altogether or separately present in all degrees of formation and chitinisation. Fig. 1 shows incomplete formation of the chitinous plate on the 8th segment, of which only the lateral parts have been formed. When all the plates are present the 6th abdominal segment carries a small plate incompletely covering the dorsal surface. The plate on the 7th segment is larger and completely covers the dorsal surface of the segment. On the 8th segment the plate is the largest of the three, and extends entirely over the dorsal and lateral aspects of the segment to the ventral surface. The median ventral surface is uncovered and this plate there embraces the segment as an incomplete ring. Anal segment heavily chitinised from apex nearly to base. Where the chitinisation ceases towards the base, there is a small uncovered area encircled by a narrow chitinous ring. This chitinous ring is exceedingly variable; it may be absent or more frequently present as a segment, or as a nearly complete ring.* On the lateral aspects of the 8th abdominal segment there are large combs composed of two rows of outwardly curved teeth. The teeth in the hind row are about the same length as those in the front row. *Siphon* black and glistening, usually about one and a half times as long as the width at its middle (widest point), the size and proportion nevertheless distinctly variable. One pair of siphonal tufts at about one-third from the base, ventrally placed. *Pecten* absent. *Anal gills* small and ovoid in form. *Anal brush* composed of long, stout, dark black hairs (Plate xxiii, fig. 1).

*Larva in Third Instar.*

Exactly similar to the fourth instar, but always without any sign of the abdominal chitinous plates. Anal segments and siphon, however, fairly heavily chitinised.

*Larva in Second Instar.*

As in the third instar, but anal segment and siphon transparent, and almost entirely unchitinised.

*Larva in First Instar.*

All the hairs on the head, thorax, and abdomen simple, or at most at certain situations bifurcated. No plumes of stellate hairs present, and no heavy chitinisation on any part of the body. Larva, including the siphon, therefore very transparent. Anal brush (fin) absent, as is the case with most first instar larvae.

*Pupa.*

Of normal form, but strongly keeled along the anterior dorsal median line of the cephalothorax. The 1st abdominal segment bears a pair of float-hairs of unusual type consisting of a mass of delicate hairs. On the 7th and 8th abdominal segments there are a pair of characteristic hair-tufts situated near the lateral apices of each segment. The tufts on the 8th abdominal segment are in the form of dense plumes, and are considerably larger than the tufts on the 7th segment.

With all the characters of the larva taken together this species could not be mistaken for any other, but it illustrates remarkably well how much certain larval characters may vary.

Adult males and females have been kept together in the same cage for several days, but so far as we were able to judge fertilisation of the females did not occur, nor were we able to induce any to "bite."

The eggs of this mosquito have not yet been found, but probably they are laid singly, or we should certainly have found "rafts" in the tree-holes in which newly hatched larvae have been present. Search for the eggs is now being made.

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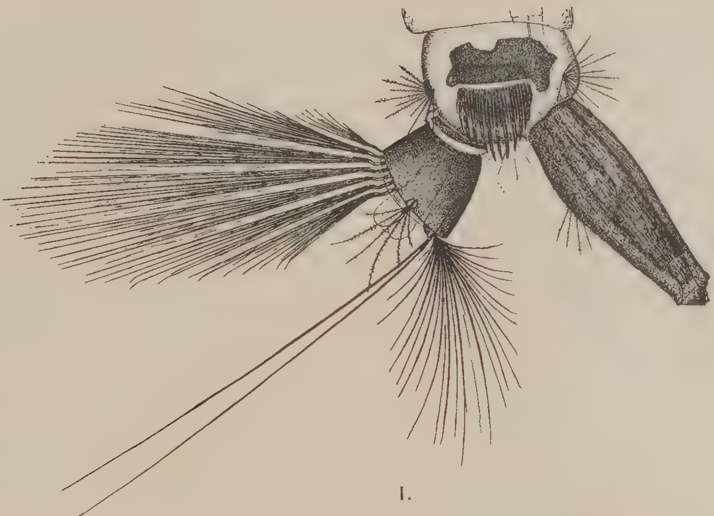
* *Note.*—These variable characters are not in any way correlated with the age of the fourth instar larva. Pupation may take place with the complete absence of any plate formation (except basal chitinisation of the combs) or with the plates present at any stage of formation up to the stage when all four plates are present and heavily chitinised.

## EXPLANATION OF PLATE XXIII.

Larva of *Orthopodomyia arboricollis*, d'Emm.

Fig. 1. End of abdomen in fourth instar.
,, 2. Head, showing extreme of variation, with dense plumes and long curved antennae.
,, 3. Head, showing opposite extreme of variation, with weakly developed plumes and short, straight antennae.
,, 4. Larva in fourth instar, showing complete development of the chitinous plates and head plumes.



1.

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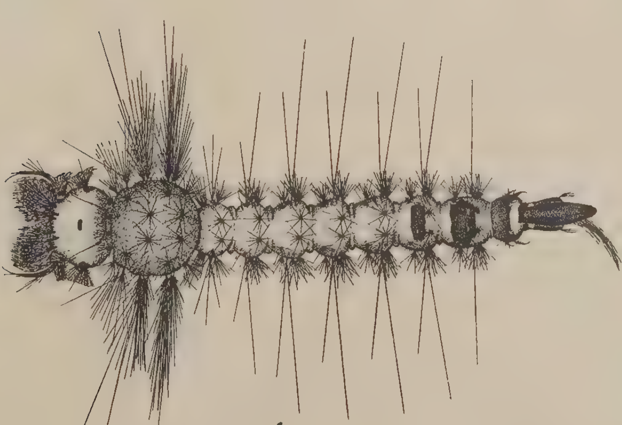

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# ON AN INTERNAL PARASITE (HYM.–CHALCIDOIDEA) OF A THRIPS FROM TRINIDAD.

By James Waterston, B.D., D.Sc.

During the past summer Mr. F. W. Urich, Government Entomologist, Trinidad, B.W.I., succeeded in rearing a number of small Chalcids from larvae of a thrips in the prepupal stage. The following description is based on part of this material.

An examination of this Chalcid emphasises the chaotic condition of the classification of the subfamily (Tetrastichinae) to which it belongs. For the present it may be placed in the genus *Tetrastichus*, Hal. Amongst its noteworthy features are (*a*) the shape and sculpture of the head and the mandible; (*b*) the swollen junction of the veins of the fore-wing; (*c*) the structure of the propodeon; (*d*) the short ovipositor and somewhat abrupt reduction of the posterior segments.

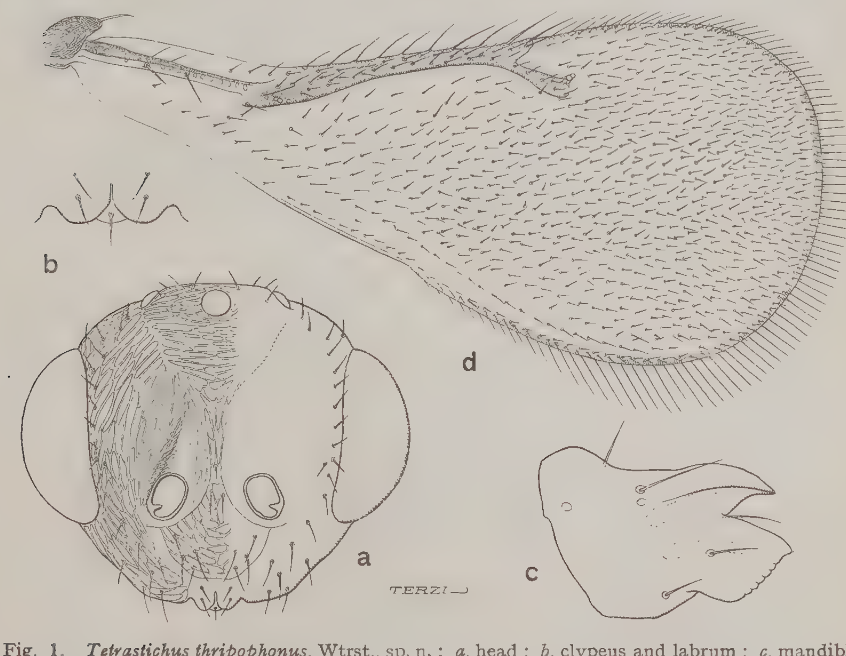


Fig. 1. *Tetrastichus thripophonus*, Wtrst., sp. n.: *a*, head; *b*, clypeus and labrum; *c*, mandible *d*, fore-wing.

## Genus **Tetrastichus.**

**Tetrastichus thripophonus,** sp. n.

♀.—A moderately shining, blackish brown species, with legs, antennae and a large basal abdominal blotch pale. Head dull dark brown. Thorax darkest, with faint purplish reflections. The basal abdominal spot extends both dorsally and ventrally over two segments. Antennae with scape yellowish; pedicel sometimes a little embrowned dorsally at base; funicle and legs (except coxae) yellowish brown. Coxae infuscated (decidedly so in hind legs) but indistinctly and narrowly pale at apex. Wings hyaline, nervures brown. In the fore-wings there is an extremely narrow darker line connecting the bases of the fringing cilia and throwing the latter more into relief.

*Head* (fig. 1, *a*) 7 : 6 ; vertex rather high and arched ; eyes salient, not large, only a little over one-half (11 : 20) the depth of the head, separated at the vertex by two-thirds and across the toruli by three-fifths of the breadth. Toruli clear of the base line of the eyes. Lateral ocelli distant from one another by one-third more than the length of either from the orbits. Genal space large, one-half the depth of the eye. Antenna (fig. 2, *a*), length 0·5 mm. ; scape (4 : 1) just longer than pedicel, ring joint and first of the funicle together, but shorter than the club ; pedicel (12 : 7) not half (3 : 7) the scape ; ring joint (fig 2, *b*) compound, with four laminae, the middle two being closely united ; funicle with i–iii equal, with a length of 21 and a breadth diminishing from 15–13 ; club, 25 : 16 : 13, with widths 18 and 10 ; sensoria of funicle 4 : 4–5 : 4 ; club, 5 : 5 : 2.

The clypeal lobes are distinct. Labrum minute, with one bristle (fig. 1, *b*). Mandible (fig. 1, *c*), upper broad lobe with about six indistinct denticles ; upper internal apodeme as large as or larger than the lower. Stipes with one lateral bristle beyond one-half, and another (minute) at same level near the middle ; maxillary palpi (5 : 1) with four bristles (subapical) ; galea with six bristles ; mentum with one bristle ; labial palpi (3 : 2) one-fifth of the maxillary palpi, with two terminal bristles, one very short and the other thrice the palpus in length ; four setigerous cells on the lingua.

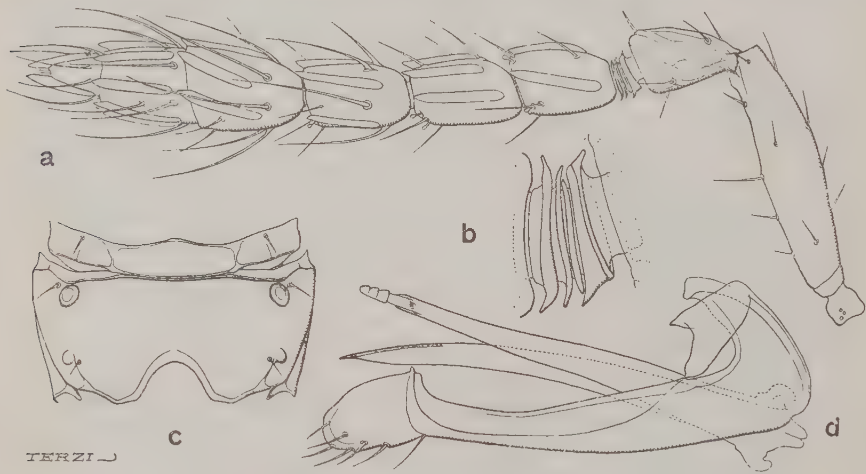


Fig. 2. *Tetrastichus thripophonus*, Wtrst., sp. n. : *a*, antenna ; *b*, ring joint ; *c*, propodeon ; *d*, ovipositor.

*Thorax* narrower (6 : 7) than head. Pronotum narrow, lateral ventral angles produced and rounded, not margined posteriorly, though more strongly chitinised round the stigma ; pattern coarse, regular, distinctly raised ; with five to six bristles on each side posteriorly, leaving about the middle third bare ; ten minute bristles along the anterior edge. Mesonotum : scutum, as long as broad, with at each side two strong lateral bristles on posterior half ; between the hinder of these and the lateral sulcus is a very minute bristle ; pattern very fine, longitudinally drawn out ; mid line faintly impressed, sub-obsolete ; parapsides with three bristles, the pattern less drawn out than on scutum ; tegulae with two bristles. Scutellum without the inner pair of impressed lines, over half (4 : 7) the scutum, truncated behind ; on each side, in a row, are one strong bristle before, one clear pustule after one-half, and one shorter bristle at the posterior edge. These rows are wide apart—three-fourths the length of the scutellum ; pattern even finer than on scutum and with difficulty distinguishable. Axillae with one minute bristle above base of wing.

Metanotum and propodeon (fig. 2, *c*) : *the latter entirely smooth and without a median keel* ; on each side postero-laterally a short, hollow, projecting knob, connected by a ridge with the posterior edge. Sternopleurae smooth and bare—one bristle at each postero-lateral angle of the sternum. Ridge between sternum and episternite indicated clearly on posterior half. Prepectus with a pattern like that of the pronotum but a little drawn out ; bare save for the minute marginal bristles.

*Wings.* Fore-wings (fig. 1, *d*) 15 : 7 ; length 0·8 mm. ; two bristles and one clear pustule on the submarginal vein ; base of the marginal vein swollen Hind-wings, 25 : 4, length 0·7 mm.

*Legs.* Fore-legs : coxae 11 : 6, surface pattern very coarse, three apical bristles posteriorly, in transverse row, 5–7 anteriorly ; femur (4 : 1) shorter (10 : 11) than tibia (15 : 2) ; on femur posteriorly in median row five bristles, three bristles widely spaced on ventral edge before one-half, one subapical ventral spinose bristle. Anteriorly about seven bristles in subdorsal row, and subapical spinose bristle ; 1st tarsal comb with 4–5 spines ; tarsus 15 : 17 : 17 : 25. Mid-legs : coxae smooth ; femur (5 : 1) much shorter (3 : 4) than the tibia (12 : 1) ; tarsus 17 : 17 : 17 : 25. Hind-legs : coxae (7 : 4) smooth, over half (4 : 7) the femur (4 : 1) ; the latter shorter (9 : 10) than the tibia (8 : 1), apical comb with six spines ; tarsus as in mid-legs.

*Abdomen* about one-third longer than the thorax and propodeon, or equal to the head, thorax and propodeon. About six-sevenths the breadth of the head or three-quarters that of the thorax on the 2nd (4th) segment or five-sixths on the 4th, *i.e.*, little expanded and not flattened but rather swollen and decurved posteriorly. Ovipositor short, about one-third the length of the abdomen ; the 1st segment is longest but less than one-third of the whole measured from the insertion of the petiole to the ovipositor tip. Measured along the mid line the tergites are approximately i (iii), 15 ; ii (iv), 11 ; iii (v), 10 ; iv (vi), 3 ; v (vii), 3. The sternites are similarly unusually reduced posteriorly, the last being not quite two-thirds the first. Integument generally quite smooth but with indications of a pattern antero-laterally on tergite i (iii). Chaetotaxy : petiole with two pleural bristles ; on each side tergites i and ii bear ten to twelve bristles, iii and iv twelve to thirteen, v six to seven, vi five and one at the spiracle ; the stylet or process on vii bears one short and three long bristles ; between the stylets are four bristles and three beyond each of the processes ; the detached sclerite (part of vii) below bears one minute bristle ; sternite i bare, ii with two bristles, iii–v with four.

*Length* about 1·4 mm. ; alar expanse, 1·9 mm. to 2 mm.

*Type* ♀ in the British Museum, one of a small series of ♀♀ bred from a thrips (prepupal stage) attacking *Clydemia* sp.

TRINIDAD : British West Indies, summer 1922 (*F. W. Urich*).

So far as I can judge, *T. thripophonus*, sp. n., is not nearly related to any of the *Tetrastichus* spp. described from St. Vincent and Grenada by Ashmead. It may, however, have close affinities with *T. gentilii*, Del Guercio (Atti dei Georgofili di Firenze (5), viii, pp. 222–227, September 1911), of which I have tried to procure a specimen for comparison, but without result.

# NOTES ON THE SMALL MOTH-BORERS OF SUGAR-CANE IN BRITISH GUIANA.

By L. D. Cleare, Jr., F.E.S.,
*Government Economic Biologist, British Guiana.*

(Plate XXIV.)

Sugar-cane is the principal crop of British Guiana, and during the year 1921 there were 65,870 acres under cultivation. This area yielded 110,985 tons of sugar and 2,228,164 gallons of rum, the value of the crop being about $10,355,000 (£2,157,200).

It has been estimated that 30 per cent. of the population of the colony is directly dependent upon the sugar industry for its livelihood, while if those indirectly dependent were included, the number would be over 80 per cent. of the entire population. It can be understood then that any insect that affects this crop to any considerable extent must be of the greatest importance.

With the exception perhaps of the giant moth-borer (*Castnia licus*, Drury), which caused very serious losses about twelve years ago, and at that time threatened the industry in this Colony, there are to-day no insects of such importance to the inhabitants of British Guiana as the small moth-borers of the sugar-cane.

## Historical.

So far back as 1879 small moth-borers appear to have been serious pests of sugar-cane in British Guiana ; indeed, records show that in that year there was a meeting of the leading sugar-planters of the Colony to discuss the situation and to enquire into the best methods of destroying these insects. In the same year Miss Ormerod, as the result of correspondence with certain estate proprietors of the Colony, published a paper in the Proceedings of the Entomological Society of London, entitled " Sugar-cane Borers in British Guiana." This may be taken as the first scientific contribution on these insects from British Guiana.

The seriousness of the situation was apparently not fully realised, for little appears to have been done at that time in controlling the insects ; indeed, it can be said that it is only very recently that it has come to be generally recognised. In 1911 there was a very serious outbreak of the giant moth-borer in the Colony, and Mr. J. J. Quelch was engaged by Messrs. Booker Bros. and Curtis Campbell & Co. to investigate that insect and recommend measures for its control. This task Mr. Quelch very effectively accomplished, but while enquiring into that insect he was able to recognise the terrible damage wrought by the small moth-borers, and immediately began the study of these insects.

About 1913 Mr. Quelch gave up his researches, which were then taken up by Mr. H. W. B. Moore. Mr. Moore is at present engaged by a number of sugar-estate proprietors to advise on methods of control and to superintend the control work on their estates. Both of these gentlemen have contributed many reports on small moth-borers and other insect pests of the sugar-cane in British Guiana.

Between 1911 and the present time Mr. G. E. Bodkin, until recently Government Economic Biologist, has contributed to the literature of these and other sugar-cane pests, principally in the Reports of the Biological Division of the Department of Science and Agriculture of this Colony.

## Life-cycle and Habits of *Diatraea*.

There are two species of small moth-borers that are particularly injurious to sugar-cane in British Guiana, while a third is sometimes found attacking it. The first two species are *Diatraea saccharalis*, F., and *Diatraea canella*, Hmp., and the third species is *Diatraea lineolata*, Dyar.

In general the life-cycles of the different species are similar; the egg period is about six days, the larval period varies from three weeks to a month or more, and the pupal period lasts about a week. There are, however, distinguishing characters for the various stages of the different species.

The eggs are oval and flattened. They are deposited in clusters, and beginning from the top of the cluster they partly overlap one another after the manner of the scales of a fish. The number of eggs in a cluster varies considerably, from two or three to as many as 100 or more, the number usually being between 20 and 40.

The eggs of *saccharalis* are smaller than those of *canella* and are generally laid in clusters of about five rows, while the eggs of the latter species are generally laid in clusters of two or three rows and bear certain red markings which are characteristic. When freshly laid the eggs of both species are of a yellowish white colour. After the emergence of the larvae the empty shells become translucent white, and their appearance has been well likened to a fragment of cast snake-skin. The eggs are generally deposited on either side of the green blades, but may also be found on the dry trash attached to the cane or on the trash on the ground, and even on blades of grass and other weeds not their food-plants.

Parasitised clusters become jet-black after a few days and retain this colour even after the emergence of the parasites; on account of their colour they are easily seen in the field. Clusters from which parasites have emerged are readily discernible by the holes made in them by the parasites in the act of emerging.

When fully grown the larvae measure about one inch long by one-eighth inch wide, and the different species are readily distinguished. In *saccharalis* the head of the larva is very dark brown, almost black, while the larva of *canella* has a bright yellow head and a black or yellow triangular mark on the 2nd body segment; they may thus be known as the "black-headed borer" and the "yellow-headed borer," respectively. Even the freshly emerged larvae show distinct differences, for while those of *saccharalis* are more or less of the same colour as the fully grown larvae, the freshly emerged *canella* larvae appear to be bright red in colour broken here and there by light bands, the head being yellowish brown. The freshly emerged *canella* larvae are also considerably larger than *saccharalis* larvae of the same age.

The moths, too, are easily distinguished, *Diatraea saccharalis* being distinctly straw-coloured, while *D. canella* is of a dark grey colour and usually larger.

*D. lineolata* is only occasionally found feeding on sugar-cane, living normally on razor grass (*Paspalum plicatum*) growing about the dams. The full-grown larvae are somewhat like those of *D. canella* in general appearance, but can be distinguished from those insects by the presence of a rod-like black mark on the 2nd segment instead of a triangular one as in *canella*.

In addition to sugar-cane, the species of *Diatraea* are known to feed on a number of other plants in this country. Some of these other food-plants are given below:—

*Diatraea saccharalis*, F., Indian corn, rice, rice-grass or shrimp grass (*Luziola spruceana*), water grass (*Paspalum gracile*), savannah prickly grass (*Paspalum* sp.), razor grass (*Paspalum plicatum* and *P. virgatum*), elephant grass (*Panicum elephantipes*) and a sedge (*Cyperus* sp.).

*Diatraea canella*, Hmp.—Indian corn and razor grass (*Paspalum plicatum*).

## Injury and Losses caused by *Diatraea*.

The injuries caused by the small moth-borers to sugar-cane are not apparent on a casual examination. True, a number of joints may be observed to have been bored with small holes, but even these give no impression of any extensive damage. It is for this reason that the insects are all the more dangerous, for the planter is led to underestimate the injury and to take a less serious view of the situation than it demands.

The first sign of the presence of moth-borers in a field is the appearance in the young plants of what is known as "dead-hearts," which term well describes the injury, for it is characterised by the young central shoot becoming yellow and finally dry, the outer leaves of the plant remaining green, at least for some days afterwards. When the young plants are but a few inches high, clusters of eggs of the moth-borer may be found on the leaves. These eggs hatch and the young larvae feed on the tender leaves of the central shoot for some time. The majority of the larvae perish during this period, for usually only one enters the young plant (but occasionally three or more). First gnawing its way through the outer stem, the larva gradually eats into the interior of the shoot, cutting the tender inner shoot across. It is usually some time before the injury is noticed, but cut off from the rest of the plant the central leaves gradually begin to wither, and eventually a typical "dead-heart" is formed. All dead hearts in a field may not, however, be caused by moth-borers, for young canes are affected in this manner by some other causes, such as by some-one accidentally stepping on a young shoot. *Castnia licus* also produces dead hearts in young canes, as also do the attacks of various fungi in their initial stages, but with experience these can soon be recognised.

While the injury to mature cane seldom proves fatal, the damage done is none the less important. As previously mentioned, the external signs of moth-borer injury are usually nothing more than a few small holes in the rind of the cane, which give no adequate idea of the amount of damage incurred. If, however, a stalk is split lengthwise, it will be seen that these holes are but the openings of excavations, about one-eighth of an inch wide, made by the insects in the interior of the cane. In these tunnels the larvae of the moth borer live, burrowing up and down the stem, and a mature cane may be found to harbour two or more such larvae at work in different parts of it. More careful examination will often reveal further injuries by borings encircling the cane about the joints in such a way that the canes often break at these places. Even when such damage occurs only in small quantities it has its ill effects, but where a large number of the joints of almost every cane are attacked the damage becomes important, and the resultant loss in tonnage of cane and manufactured sugar is considerable.

A very important part of the injury occurs to the "seed piece," or "top" of the cane. A large percentage of such "tops" are infested with moth borer larvae, and when these tops are planted without treatment the contained larvae form an important source of early infestation to the field.

That borer holes also serve as entrances for fungus diseases has been pointed out by other workers.

The injuries caused by the small moth-borers may then well be summarised in the words of Holloway and Loftin, who say that "Cane badly bored is found to be hard and dry, making it difficult to grind. The growth is checked, and the bored stalks are often blown down by a strong wind. The purity of the juice is lowered, the tonnage decreased, and the sucrose content materially diminished. The eyes are destroyed in many cases, which lessens the value of the infested cane for seed."

For the purpose of obtaining an accurate idea of the amount of damage done by these insects careful examinations were made of a number of fields. The method adopted was a modification of that used by Holloway and Loftin in their investigations on the small moth-borer in the United States of America.

In each field 100 stalks were examined, taken in five groups of 20 each at regular distances throughout the field. The number of stalks and the number of joints damaged were counted and the percentages worked out. In estimating the number of joints damaged every joint with a borer hole was considered as damaged, and while it is fully recognised that a large number of such holes must be exit holes, in view of the fact that a larva seldom bores a single joint, it is considered that this method can be taken as fairly representative. From the figures obtained during such

examinations it has been found that an average infestation of 93 per cent. of stalks and 28 per cent. of joints attacked is not unusual. While the percentage of stalks damaged gives some idea of the amount of injury, a more accurate estimate of the loss caused by the insects can be obtained when the percentage of joints damaged is also taken into consideration.

Table I gives the infestation of stalks and joints in plant-canes, 1st, 2nd, and 3rd ratoons and old canes, on two plantations.

TABLE I.

*Infestation of Plant and Ratoon Canes.*

| | Plant Canes. | | 1st Ratoons. | | 2nd Ratoons. | | 3rd Ratoons. | | Old Canes. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Stalks. | Joints. | Stalks. | Joints. | Stalks. | Joints. | Stalks. | Joints. | Stalks. | Joints. |
| No. 1 .. | 83·8 | 17·5 | 94·2 | 26·9 | 94·5 | 21·7 | 87·5 | 19·0 | 93·5 | 19·0 |
| No. 2 .. | 90·0 | 24·3 | 96·0 | 26·3 | .. | .. | 91·0 | 31·3 | 95·2 | 31·4 |
| Average | 86·9 | 20·9 | 95·1 | 26·6 | 94·5 | 21·7 | 89·2 | 25·1 | 99·3 | 25·2 |

The lowest infestation was 11·0 per cent. of joints attacked in a field of plant-canes, while the highest infestation was in a field of old canes, of some nine years standing, which showed 43·2 per cent. of the joints attacked.

The question of the relationship of the ratooning period to infestation by moth-borers will be dealt with elsewhere.

A very important part of the injury occasioned by small moth-borers is that which occurs to the "seed-piece" or "top" of the cane. When the cane has reached maturity it is this part of the plant that principally harbours moth-borer larvae, and if such tops are planted without treatment, as is the general rule, a large proportion of the larvae they contain continue their development in the tops after planting, either directly entering the young shoots as they spring from the top, or emerging as moths and forming a source of early infestation for the young plants. Many hundreds of tops examined showed that an average of 14·2 per cent. are so infested. In examining them, only tops that actually contained larvae or pupae at the time of examination were considered affected. Tops that had been bored but at the time contained neither larvae nor pupae were considered as unaffected and counted as borer-free tops. Of the unaffected tops 35·2 per cent. showed such borings, so that only 50·4 per cent. of the tops were sound. Of the infested tops 9·0 per cent. were found to contain *canella* larvae, 3·7 per cent. *saccharalis* larvae, and 1·5 per cent. pupae.

### Factors influencing the Prevalence of the Moths.

*Early Infestation of Plant Fields from "Old Banks."**

Artificial dissemination plays a very important part in the early infestation of fields, probably the most important source in plant fields being the "old banks,"* or "false rows," as they are sometimes called. When a field is replanted this is done between the rows of the old crop, and the old stools are not forked out till later; consequently shoots spring from them, forming the "false row." Very often these attain the height of three feet before the tops have sprung more than six inches (Plate xxiv, fig. 1). On occasions it has been observed that the old stools attained this height even before replanting was commenced, and it was necessary to weed the field preliminary to planting.

When the "old bank" has reached this height, if the stools are not required for "stumps,"* they are weeded down and thrown on the "trash bank,"* only to be a further danger to the tops. The borers they harbour, having their food supply thus suddenly cut off, either pupate, if they are far enough developed to do so, or leave the shoot, and in their search for food enter the tops. If these trash banks be examined a few days after they have been weeded, they will be found to contain many such larvae, and as many as 12 full-grown larvae, in a prepupal stage, have been found in one of these banks (a distance of 37 feet), while small larvae can be found trying to bore into pieces of hard cane about the trash bank.

It is the general practice, whenever possible, to fork both banks in plant fields. Under the present system the new rows are forked and planted with tops, and after a period varying from one to several weeks one of the old banks is forked, the old stools being turned under. The trash, which up to that time has been on the other old row, is now transferred to the forked bank, the process being known as "changing banks." A further period then elapses, varying also to several weeks, before the second bank is forked. During the interval the remaining old stools spring to about three feet again, and, as before, harbour borers.

Table II gives the results of examinations of three such fields, and shows this early infestation from the old banks. The first examination was made when the rows were about 12 inches high, the old bank at the time being two or three feet high, and in most instances was then undergoing weeding to allow the tops a chance. The second examination was made about a month later when the rows were about 18 inches high, the old banks being then about the same height.

TABLE II.

*Examination of Plant Fields showing Infestation of Rows from Old Banks.*

| Field. | Percentage of shoots infested 1st Examination. | | Treatment of Field. | Percentage of shoots infested 2nd Examination. | | Difference of Infestation. |
|---|---|---|---|---|---|---|
| | Row. | Old Bank. | | Row. | Old Bank. | |
| No. 1 | 4·9 | No O.B., weeded down. | One Bank forked already. | 4·7 | .. | Nil |
| No. 2 | Nil. | 10·8 per cent. O.B. just being weeded. | One bank forked | 6·8 | One O.B. remaining 18 inches high. Infestation heavy; not estimated. | Increase, 6·8 |
| No. 3 | 2·7 | 7·7 per cent. Both O.B. present. | One bank forked about 12 days before 2nd exam. Both O.B. weeded. | 9·3 | One O.B. remaining 18 inches high. Infestation heavy; not estimated, but gang working this field, got most borers from O. B. See figures below. | Increase 6·6 |

* See Appendix.

Further proof of this greater infestation in the field in which the old bank is left is given by the collections of the gang* from these fields. These figures are given below.

| *Field.* | *Larvae collected.* | *Clusters collected.* |
|---|---|---|
| No. 1 | 6,630 | 462 |
| No. 3 | 19,910 | 1,732 |

It can be readily seen from the above that these old banks actually foster moth-borers, causing a much higher infestation in the plants than would otherwise occur. The obvious thing to do is to fork both banks as soon as the tops are planted.

*Planting Borer-free Tops.*

Provided that both banks are forked and the trash is buried, the next most important source of early infestation in plant fields is the tops themselves. The selection of borer-free tops for planting has been recommended by Quelch and Moore, but it has been invariably objected to from the point of view of labour supply. It must be admitted that this is a serious drawback, and it is questionable if such selection could be practised on estates in the Colony at the present time.

Bearing this in mind, it appeared that some method of treatment for seed-cane would be necessary. Such experiments have been carried out by Holloway and Loftin, as well as others, but they did not prove effective in the destruction of moth-borer larvae. The treatment, however, in no instance extended for more than one hour.

Local conditions suggested the immersion of tops in water, for with a very complete system of canals as exists on estates in this Colony, and punts for transportation, it would be both practical and cheap. With this object in view experiments were carried out on the immersion of tops in vessels containing water for periods varying from 24 to 72 hours. The results of these experiments are given in Table III.

TABLE III.

*Effect on Moth-borer Larvae of Immersion of Tops.*

| Time soaked, hours. | No. of tops soaked. | Number of borers found. | | Number of borers killed. | | Percentage mortality. | | Total mortality, per cent. |
|---|---|---|---|---|---|---|---|---|
| | | Larvae. | Pupae. | Larvae. | Pupae. | Larvae. | Pupae. | |
| 24 | 100 | 10 | 2 | 9 | 2 | 90·0 | 100·0 | 91·6 |
| 24 | 100 | 6 | 0 | 4 | 0 | 66·6 | .. | 66·6 |
| 40 | 100 | 11 | 5 | 10 | 5 | 90·7 | 100·0 | 93·7 |
| 45 | 100 | 25 | 9 | 24 | 8 | 96·0 | 88·8 | 94·1 |
| 48 | 53 | 12 | 3 | 11 | 3 | 91·6 | 100·0 | 93·3 |
| 48 | 375 | 103 | 43 | 85 | 43 | 82·5 | 100·0 | 87·6 |
| 48 | 100 | 11 | 3 | 10 | 3 | 90·9 | 100·0 | 92·8 |
| 48 | 100 | 5 | 0 | 5 | 0 | 100·0 | .. | 100·0 |
| 62 | 203 | 21 | 8 | 18 | 8 | 85·7 | 100·0 | 89·6 |
| 72 | 200 | 13 | 7 | 12 | 7 | 92·3 | 100·0 | 95·0 |
| 72 | 214 | 16 | 2 | 16 | 2 | 100·0 | 100·0 | 100·0 |
| 72 | 365 | 12 | 4 | 12 | 4 | 100·0 | 100·0 | 100·0 |
| 84 | 377 | 23 | 7 | 22 | 7 | 95·6 | 100·0 | 96·6 |

It will be seen from the above that 72 hours' immersion in water kills all the moth-borer larvae and pupae contained in the tops.

* See page 465.

To test the effect of the immersion of tops on their germination, three punts of tops were submerged in a canal and after soaking for 72 hours the tops were planted out in a field. No attempt was made to treat the tops in any manner different from the treatment they would receive under practical conditions. The variety of cane used was D625. The germination of the soaked tops was then compared with the germination of adjacent unsoaked tops. Table IV gives the result of this experiment. It will be seen that the soaked tops showed 1 per cent. less dead-hearts than the unsoaked ones; in addition, the number of shoots per top in the soaked tops was 2·9 as against 2·5 shoots per top in the unsoaked tops; and the percentage of tops dead is greater in the soaked tops, being 10·3 per cent. as against 9·4 per cent. in the unsoaked tops.

TABLE IV.

*Germination of Soaked and Unsoaked Tops.*

| Treatment. | No. of Bed. | No. of Tops. | No. of Shoots. | Per cent. Deadhearts. | Average No. shoots per top. | Per cent. Tops dead. |
|---|---|---|---|---|---|---|
| Soaked Tops .. | 1 | 959 | 2,941 | 0·9 | 3·0 | 4·0 |
| | 2 | 1,339 | 4,089 | 0·4 | 3·0 | 6·4 |
| | 3 | 1,321 | 4,083 | 0·4 | 3·0 | 8·8 |
| | 4 | 1,294 | 3,691 | 0·6 | 2·8 | 14·5 |
| | 5 | 1,229 | 3,521 | 0·3 | 2·8 | 19·0 |
| Unsoaked Tops | 1 | 912 | 1,659 | 2·2 | 1·8 | 7·0 |
| | 2 | 1,156 | 2,876 | 1·7 | 2·4 | 5·7 |
| | 3 | 1,237 | 2,993 | 1·0 | 2·4 | 7·5 |
| | 4 | 1,234 | 3,618 | 1·4 | 2·9 | 13·6 |
| | 5 | 1,209 | 3,658 | 0·7 | 3·0 | 13·3 |

*Refuse Tops in Fields.*

Probably the most important source of early infestation is to be found in the refuse tops left in fields. While the infestation from old banks, and tops used in planting, applies principally to fields that are being replanted, the infestation occurring from refuse tops takes place in ratoon fields. It also affects plant fields when the tops discarded as being unfit for planting are left on the parapets of the fields, if such tops have not previously received some treatment for the destruction of the contained moth-borers.

It is the usual practice to cut tops for planting whenever a field is being reaped, and after the canes have been removed, the tops remain in the fields for periods ranging to a couple of weeks or even more before they are collected for planting, and even after such collections are made, a large number of tops are still left in the fields, either as being unfit for planting or through oversight.

In order to demonstrate this point nine lots of 25 tops each were collected in the field and kept in the laboratory for observation, and after a month were examined and their condition noted. The emerging moths were noted, and the tops were examined for any moth-borer larvae or other insects they might contain.

These examinations showed that 23·1 per cent. of the tops contained *canella* larvae, while only 5·7 per cent. contained *saccharalis* larvae. Of the total number of larvae found over 85 per cent. were those of *canella*. Living pupae were contained in 3·5 per cent. of the tops, and moths had emerged from 8·4 per cent. The borer-free tops comprised 37 per cent. of the total number of tops, and 19 per cent. possessed empty *Diatraea* borings. Weevils (*Metamasius hemipterus*, L.) occurred in 8·4 per cent. and termites in 3·1 per cent., while 0·8 per cent. of the tops showed mealy-bug (*Pseudococcus*) still alive.

*Stumping.**

The habit of supplying fields with "stumps,"* as is often practised, cannot be looked upon in any other light than one fraught with dangers. Insect pests, such as *Castnia* and termites, as well as fungus diseases like *Marasmius*, are liable to be disseminated in this way, while from a purely agricultural point of view it would appear to be inadvisable.

It should be remembered that in planting a stump one is doing nothing more than planting into a field ratoons of the age of the field from which the stumps were obtained, often many years older than the field into which they are being planted. There is some little argument in their favour from this point of view when the supplying is being done to ratoon fields of some years' standing, but even this point disappears in the case of plant fields, while to plant entire fields of stumps would appear to me to have no advantage whatever.

It is realised that when the plants in a field have reached, say, five feet in height, supplying with tops is hardly advisable, but if supplying could not be carried out before this, the difficulty could be got over by using stumps raised from tops in a nursery or field set aside for the purpose, and not dug haphazard from any field on the estate.

*Ratooning Period.*

From a number of estimates of infestations made during last year it would appear that the ratooning period and the infestation of borer show some relationship. Thus plant-canes are invariably less affected than ratoons, the infestation gradually increasing year after year and attaining its highest point in "old canes." The average infestations during the year were found to be: plant-canes 20·9 per cent.; 1st ratoons 26·6 per cent.; 2nd ratoons 21·7 per cent.; 3rd ratoons 25·1 per cent.; and old canes 25·2 per cent.

The infestation varied somewhat, and the percentages of joints affected were found to be: in plant-canes from 11 to 29 per cent.; in 1st ratoons from 19 to 37 per cent.; in 2nd ratoons from 15 to 21 per cent.; in 3rd ratoons from 11 to 31 per cent.; and in old canes from 16 to 43 per cent. These figures, it must be remembered, are for one year only, and from a small number of fields, so that the error will be somewhat high.

The amount of "old canes" in cultivation should therefore be reduced to a minimum, and should never be more than one-fifth of the total area under cultivation, if possible. In the same manner, plant-canes and 1st, 2nd and 3rd ratoons should be of the same area; in other words, the cultivation should be divided into five equal parts according to the ratooning periods.

From every point of view the advisability can be seen of replanting fields every five years at most, while periods of four years would be preferable. The practical planter often puts forward against this system the argument that if a field is giving a good return—and two tons per acre is considered a good return—why should it be replanted? The answer to this is in the form of two other questions: How many fields of over five years' standing (4th ratoons) are giving two tons per acre? and, Why not replant the field and get a greater yield, which will more than repay the cost of replanting and at the same time reduce the borer infestation?

It might even seem advisable to abandon some of the area under cultivation, where necessary, and with a smaller area obtain the same total yield. The concentration of labour and expenditure would make for better cultivation and control, and probably a larger yield per acre, while the number of fields of old canes that are nothing but a drain on the returns would to a large extent disappear.

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* See Appendix.

Many estates in the Colony have as much land abandoned as there is in cultivation, and by taking advantage of this fact it would appear that more beneficial results could be obtained. If the area to be planted each year was taken from these abandoned long-rested or water-fallowed fields, instead of replanting fields that had just reached the fourth-ratoon stage, and which had possibly been in continuous cultivation for three times as many years, the yield of plant-canes would probably be increased, while after six years there would be no field on the estate that had been in continuous cultivation for more than five years, so that even the old canes (4th ratoons) should be giving fairly remunerative returns.

## Control Measures.

*Collection of Egg-clusters and Larvae.*

The method of control usually employed in British Guiana is that known as "cutting out." In this method a gang of children are employed to go through the field cutting, by means of sharp knives, the "dead-hearts" caused by the moth-borer. Each shoot showing a dead-heart is cut off close to the ground, opened, and the larva or pupa it contains removed and kept in a small tin until the end of the day, when they are counted and destroyed. The insects are paid for by the hundred, the rate varying slightly according to their prevalence, being usually about six cents. (3d.) per hundred. The number of individuals employed in this way varies considerably, both according to the prevalence of the insects and the interest taken in the work by the management, but a gang of fifty persons is in no way unusual. The children employed at this work become very skilful at it, and often earn as good wages as do adults engaged in more arduous labour.

Besides cutting out dead-hearts these gangs invariably collect egg-clusters, doing much useful work in this manner. These are also kept in small tins and counted at the end of the day. They are, however, not immediately destroyed, as will be explained later. This part of the work is very important, and when carried out at the correct time cannot be too highly recommended. Egg-clusters are paid for at the rate of one or two for one cent. (½d.).

Practically every sugar estate in the Colony carries out these control measures, and it can be said that they are effective in keeping the number of borers in subjection, while the benefits derived from the work amply repay the cost of carrying it out.

While these methods of repression are sound and can be said to have given good results, they are largely dependent upon an adequate supply of cheap labour, and therefore cannot always be recommended. The success of such work, however, also largely depends on its being carried out continuously and systematically, and not waiting until fields show a large number of dead-hearts before commencing work upon them. With a well arranged system not only are better results obtained, but the size of the gang can be much reduced.

The mere collection of eggs and their subsequent destruction does not allow of the greatest efficiency being obtained from this part of the work, and not the least important part is the returning of parasitised clusters to the fields from which they were obtained. Under natural conditions in the field a number of the eggs laid are parasitised, and while they give no indication of this at the time, it follows that if the clusters collected by the gangs are destroyed immediately it would result in the destruction of very many parasites that would be of the greatest value in the field. It has been found that this can be avoided if the eggs are kept for four days, at the end of which time any that have been parasitised in the field will have turned black, and such clusters can then be returned to the fields from which they were collected.

This method had been used by Quelch and Moore in their work in this Colony. The method may be summarised as follows. Each day's collection of clusters is kept in a separate tin labelled according to the day of the week, the cover of the

tin being slightly tilted to allow of the egress of any caterpillars that hatch within the tin. Each tin is placed in a shallow pan containing a mixture of water and kerosene or molasses, so that any larvae that emerge from the tins will crawl into the liquid and be destroyed. It is advisable to have a few holes bored about the bottom of the tin to allow of a circulation of air and so avoid over-dampness and the growth of mould. After four days the eggs are examined, and any that have turned black are kept as being parasitised, the remainder being burnt, and the tin left empty to receive the collection of the same day of the following week.

The parasitised clusters are then placed in cigarette or other small tins, and returned to the fields from which they were collected. The tins containing parasitised clusters are put out in the field in small wooden boxes, eight inches square, opened at one side and hooked upon a stake about four feet in length driven into the ground (Pl. xxiv, fig. 2). The open side of the box should be away from the prevailing wind. Parasitised clusters should remain in the field about five days, after which time the parasites will have emerged and the tins can be used for fresh supplies.

*Collection of Parasitised Clusters before Reaping.*

It can be readily seen that the method of burning fields previous to reaping, which is in general practice, must destroy a large number of insects in the fields. If this destruction worked equally against the moth-borer as against its enemies something might be said in its favour from this point of view. Unfortunately the very opposite is the case, and while the burning destroys a very large number of parasites, probably the majority of moth-borer larvae are unaffected by it. This fact is amply borne out by the number of larvae found in the tops alone. When a sufficient supply of labour is available this waste of parasites can be largely avoided by sending a gang through the fields, previous to burning, to collect the black parasitised egg-clusters. These clusters, on account of their coloration, are easily seen on the leaves, and a gang working conscientiously will bring in fair numbers. Care must be taken to see that eggs from which the parasites have already emerged are not accepted, for unlike those from which the larvae have emerged, they do not change colour after this has occurred, and they can only be recognised by the tiny emergence holes made by the parasites. The parasitised clusters obtained in this way are sent to young fields in which the parasitism is not high, and in such fields the parasites do useful work.

*Parasitic Enemies.*

The small moth-borers have several natural enemies in British Guiana, and there is not the slightest doubt that they serve to keep the pest in control to a very large extent. The following is a list of those insects known to be parasitic on small moth-borers in this colony :—

Egg parasites :—*Trichogramma minutum*, Riley, and *Prophanurus alecto*, Cwfd.

Larval parasites :—*Iphiaulax medianus*, Cam., *Iphiaulax* sp., *Cremnops parvifasciatus*, Cam., *Mesostenoideus* sp., and an undetermined species of Dexiid fly.

Pupal parasites :—*Heptasmicra curvilineata*, Cam.

The biological control of small moth-borers appears to offer many possibilities in British Guiana, and for the past year the writer has been engaged on this work, especially in connection with the rearing of the egg-parasites, *Trichogramma minutum*, Riley, and *Prophanurus alecto*, Cwfd. Although the work has been in operation for only one year it has apparently been attended with favourable results. An account of the rearing of these parasites will be published at a later date.

**Recommendations for the Control of Moth-borers.**

1. The forking of both banks as soon as the tops are planted, and the consequent elimination of " false rows " or old banks.

2. Treatment of tops previous to planting by immersion in water for 72 hours. If the tops are so treated there will be no necessity for selection of borer-free tops for planting.

3. The destruction of refuse tops and pieces of cane left in the field, either by ploughing-in or burning. This would do much to eliminate attacks of weevil (*Metamasius hemipterus*, L.) and termites, while, if the trash was buried at the same time, it would probably have a marked effect on the number of *D. canella* larvae through the destruction of their eggs.

4. The abolition of "stumping" so far as possible. Any "supplying" should be done with "tops" soon after planting.

5. The reduction of the acreage under "old canes" to a minimum, and, where possible, such old canes not to exceed fourth ratoons. The replanting of at least one-fifth of the acreage yearly, such replanting to be carried out in long rested or water-fallowed fields and not in fields that have been in continuous cultivation for a long period of years.

6. The employment of gangs to collect egg-clusters and larvae of moth-borers from the fields. This method of control is still practical in British Guiana and should be employed until such other control measures are devised that can supersede it.

7. Returning of parasitised clusters to fields from which they were obtained. Where labour conditions allow, the collection of parasitised clusters from fields previous to their being reaped, and the distribution of such parasitised clusters amongst the fields that most need them.

8. The artificial rearing of the egg-parasites, *Trichogramma minutum*, Riley, and *Prophanurus alecto*, Cwfd., as well as such larval parasites as *Iphiaulax medianus*, Cam., and the Dexiid fly parasite, is regarded as showing signs of promise as a practical means of control.

The investigations described in this paper were carried out during the past eighteen months while employed as entomologist to Messrs. S. Davson & Co. Ltd., Berbice. I should like to express my thanks to Mr. W. M. B. Shields, and especially to Mr. J. R. C. Gordon, as well as to Mr. A. E. De Groot, of that firm, for the facilities given me while so employed, and to Mr. J. Crabtree, M.Sc., Superintendent of the British Guiana Sugar Planters' Experiment Stations, for the valuable criticisms and assistance given throughout the investigations.

## Appendix.

J. Crabtree (A Report on Agric. Conditions of Cane-sugar Industry in Brit. Guiana, 1921) gives the following description of the system employed in this Colony in the cultivation of the sugar-cane. The description is given here to enable those unacquainted with the system to understand better the practices referred to in this paper.

"The process of winning land from the sea, or 'empoldering,' as it is termed, consists in surrounding the area to be taken in by dams sufficiently high to keep out surrounding water at any state of the tide. The one in front along the seashore is the 'sea dam' and serves to keep out the sea; parallel to this at the extreme inland limit of the area empoldered is the 'back dam' keeping out water from the savannahs in the wet seasons, and the sides are protected by the dams joining, and at right angles to, the two former, thus enclosing a parallelogramatic area which becomes the estate. To obtain earth to construct the dams, trenches have to be dug on either side of them and the ones on the inside are used as navigation or draining trenches, as the case may be. Another dam (with trenches) is made down the middle of the estate called the "middle-walk," and at intervals other trenches are cut at right angles to these on each side and extending to the sides of the estate, thus dividing the latter into square or rectangular fields, access to which is gained by this system

of trenches full of water, along which large punts can be drawn by mules. (These trenches also, when occasion demands, provide a means of irrigating the fields; they are supplied with water from the savannahs or from inland creeks, this water being conserved for the purpose). Each field in its turn is divided into a number of long parallel beds by narrow drains two to three feet deep, which extend the whole width of the field and discharge into the main drainage or 'side-line' trenches, which have ultimate access to the sea in front through a large wooden door or sluice, which is closed when the level of the sea-water rises above that in the drainage trenches. The beds referred to are on an average three rhynland rods in width (37 feet) and of varying lengths, from 30 rods upwards.

"The fields having been cleared of all trees, bush and weeds, rows are marked off across the beds at right angles to the small drains five, six, seven, or even eight feet apart, as the case might be. The space between two rows is known as a 'bank,' and two adjacent banks constitute an 'opening.' A sort of wide shallow drill is first made along each row, half the width of the distance between the rows, the excavated earth being placed on each side, forming raised 'banks.' The earth along the drill, over a width of about two feet, is then dug about nine inches deep and the cane pieces or 'tops' inserted in the ground at an acute angle, at regular intervals, from one to two feet apart. The field is then left until the shoots appear and weeds spring up between the rows, when the latter are chopped off flush with the ground by cutlasses and a little earth scraped up round the cane shoots. The weeds are placed on one of the banks of the opening, which is then termed a 'trash bank.' Later, labourers cultivate each 'clean' bank, as the other bank is termed, with four-pronged forks to a depth of eight or nine inches; they also mould up the cane roots further. At intervals, as is found necessary, the land is again weeded until the canes are high enough to shade the ground sufficiently to keep down further weed growth. The dead leaves or 'trash' may also be removed from the canes at the time of weeding and of course placed on the 'trash' bank.

"When, at an age of about 15 months, the plant-canes are ready to cut, the fields are set on fire, thereby consuming the major portion of the dead leaves and facilitating the handling of the canes. The canes are then cut close to the ground, the green 'tops' trimmed off and retained for seed-pieces, and the cane-stalks carried out to the punts waiting in the navigation trenches and thus conveyed to the mill.

"After cutting, the rows are 'relieved' of the trash lying about them by gathering this and placing it on the trash bank. Usually the trash in this crop is transferred on to what was the 'clean' bank. The trash bank thus becomes the clean bank and as such is dug over, the banks thus receiving one forking every two years. Nowadays, however, both banks are usually forked in the same year. The soil around the cane-roots is dug after relieving, after which the operations performed are similar to those described for the plant crop, except that the canes are cut when about 12 months old. This crop is termed the first "ratoon" crop, the yield from subsequent ones becoming the second, third, etc., ratoons. Ratoon crops usually diminish gradually with each succeeding crop, until, when the returns are not regarded as satisfactory, the field is 'renewed' or replanted by forming new rows down the centres of the banks, and proceeding as before after digging out the old stumps.

"Thus the land is continually under a crop of cane and many fields have been in continuous cultivation for periods varying up to a century or even more."

"*Supplying*."—When a field is allowed to ratoon, some of the stools usually fail to spring. These deficiencies are replaced by "supplying" the field. Supplying is either accomplished with "tops" or "stumps."

"*Stumps*."—Old stools dug from other fields (usually from the old banks of fields that are being replanted) and used to supply deficiencies elsewhere.

Fig. 1. Field of sugar-cane showing "old banks" with young plant canes (X) growing between them.

Fig. 2. Parasite-distributing box in position in field.

# ON A SMALL COLLECTION OF COCCIDAE FROM MESOPOTAMIA, WITH DESCRIPTION OF A NEW SPECIES.

By E. Ernest Green, F.E.S., F.Z.S.

The collection was received through the Deputy Director of Agriculture (Research) and contained the following species, collected by the Assistant Entomologist, Rao Saheb Y. Ramachandra Rao :—

*Pseudococcus citri* (Risso), on grape vine.
*Asterolecanium phoenicis*, sp. n., on date palm.
*Phoenicococcus marlatti* (Ckll.), on date palm.
*Parlatoria blanchardi*, Targ., on date palm.
*Parlatoria calianthina*, Berl. & Leon., on olive, oleander, rose, mulberry and *Zizyphus*.

**Asterolecanium phoenicis,** sp. n.

Sac of adult female pale, translucent, greenish yellow ; the body of the insect revealed as a reddish brown median patch. Long ovate, narrowed posteriorly, moderately convex. Marginal fringe moderately long ; close and continuous, except on the posterior fifth, where it is wanting. Length 1·5 to 1·25 mm. Breadth averaging 0·75 mm.

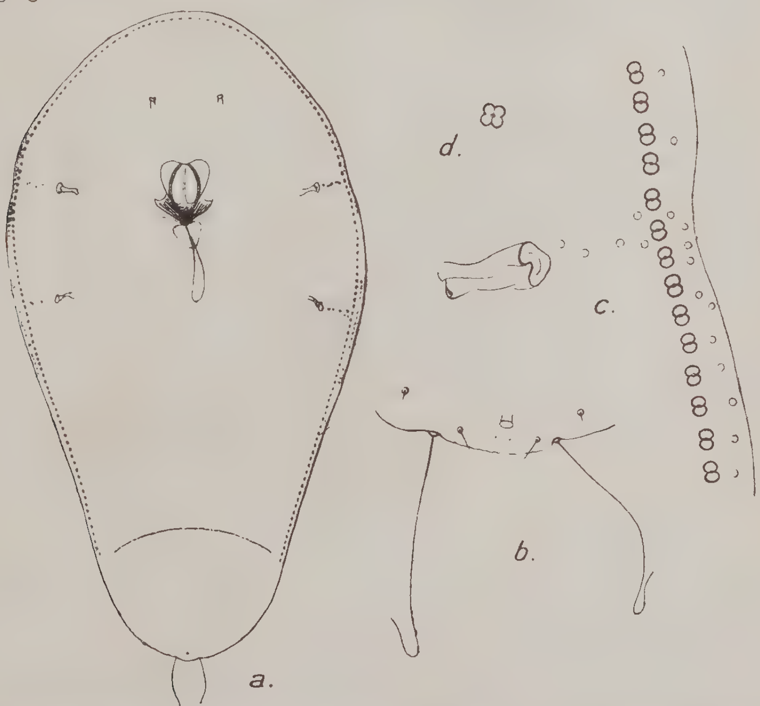


Fig. 1. *Asterolecanium phoenicis*, Green, sp. n. : *a*, adult ♀, × 80 ; *b*, posterior extremity, × 450 ; *c*, marginal pores and anterior spiracle, × 450 ; *d*, abnormal quadrilocular pore, × 450.

Adult female insect (fig. 1*a*) slipper-shaped, narrowed behind ; posterior extremity evenly rounded. Rudimentary antennae each with two small but relatively stout

setae. Mouth-parts rather large and conspicuous. Anal orifice minute and simple, without setiferous anal ring. Caudal setae slender (fig. 1*b*). Margin (fig. 1*c*) with a close series of conspicuous paired pores, terminating at some distance from the posterior extremity, which is demarked by a curved transverse crease. A scattered series of simple circular pores extends from each spiracle to the margin, and along the margin for some distance on each side of the stigmatic areas, but absent elsewhere. No supplementary paired pores on the dorsum. An abnormal double paired pore (fig. 1*d*) was observed in the marginal series of one example. Body with numerous cylindrical tubular pores disposed in more or less distinct clusters. Length 1 to 1·25 mm. Breadth approximately 0·75 mm.

On the leaf-stalks, leaves and fruits of the date palm (*Phoenix dactylifera*); Baghdad, Mesopotamia.

The absence of a definite setiferous anal ring is unusual in the genus *Asterolecanium*, but this condition occurs in an Australian species—*A. hilli*,* as also in the allied genus *Polea*.† In *A. ceriferum*‡ and *pudibundum*§ there is no apparent setiferous ring; but in those species the anal tube is more complex, consisting of several conspicuous invaginations of the rectum.

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* Bull. Ent. Res. vii, pt. i, May 1916, p. 63.
† Mon. Cocc. Ceylon, v, p. 462.
‡ Mon. Cocc. Ceylon, iv, p. 324.
§ Mon. Cocc. Ceylon, iv, p. 323.

## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st October and 31st December 1922, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Capt. Baker :—9 Coleoptera and 7 larvae, 20 Ants, 20 Isoptera, 6 Mites and 4 Millipedes ; from the Gold Coast.

Mr. H. A. Ballou, Entomologist, Imperial Department of Agriculture :—4 Lepidoptera, 2 larvae, and 6 pupae ; from Trinidad.

Mr. G. A. H. Bedford :—16 Culicidae, 4 Tabanidae, 8 Hippoboscidae, 5 *Simulium*, and 70 other Diptera ; from South Africa.

Dr. J. O. Beven :—32 Tabanidae, 28 *Glossina*, 8 Hippoboscidae, 48 other Diptera, 33 Coleoptera, 22 Hymenoptera, 2 Lepidoptera, 15 Rhynchota, and 3 Orthoptera ; from Kenya Colony.

Dr. Bodenheimer :—66 Orthoptera ; from Palestine.

Mr. G. E. Bodkin, Government Entomologist :—2 Hippoboscidae, 53 Coleoptera, and 10 species of Coccidae ; from Palestine.

Dr. de Boer :—235 Culicidae ; from Kenya Colony.

Dr. Chas. K. Brain :—56 Rhynchota ; from South Africa.

Mr. G. H. Bryan, Jr. :—139 Rhynchota ; from Hawaii.

Dr. P. A. Buxton :—57 Siphonaptera, 75 Culicidae, 4 Tabanidae, 9 Hippoboscidae, 35 other Diptera, 107 Coleoptera, 203 Chalcididae, 2 other Hymenoptera, 3 Lepidoptera, 9 Rhynchota, 175 Orthoptera, and 100 Anoplura ; from Palestine.

Dr. J. M. Clark :—3 Culicidae, 9 *Glossina*, 1 tube of Hippoboscidae, 23 other Diptera, and 7 Ticks ; from Tanganyika Territory.

Mr. L. D. Cleare, Jr., Government Entomologist :—3 Diptera, 12 Rhynchota, and 3 tubes of Parasites of *Brassolis sophorae* : from British Guiana.

Mr. M. T. Dawe :—2 species of Coccidae ; from Sierra Leone.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist :—1,009 Coleoptera ; from India.

Mr. G. F. Hill, Entomologist, Australian Institute of Tropical Medicine :—80 Culicidae, and 2 Chironomidae ; from Australia.

Capt. R. Hingston :—9 Orthoptera ; from Bombay, India.

Dr. W. Horn :—5 Tabanidae ; from Cuba.

Mr. J. C. Hutson :—29 Coleoptera and 40 Lepidoptera ; from Ceylon.

Dr. J. F. Illingworth :—4 Diptera ; from Hawaii.

The Irai Co., Ltd., London :—293 Coleoptera ; from the Federated Malay States.

Mr. R. W. Jack, Chief Entomologist, Department of Agriculture :—4 Bombyliidae and pupa cases, 105 Parasitic Hymenoptera, and 6 Mutillidae ; from Southern Rhodesia.

Dr. W. B. Johnson and Dr. Ll. Lloyd :—21 *Glossina tachinoides* attacked by Mites, and 6 Ticks ; from N. Nigeria.

Dr. W. A. Lamborn :—102 Diptera, 157 Dipterous larvae parasitised by Chalcids, 36 Coleoptera, 1,061 Parasitic Hymenoptera, 7 other Hymenoptera, and 4 Lepidopterous larvae parasitised by Chalcids ; from Nyasaland.

Dr. A. da Costa Lima :—11 Coleoptera ; from Brazil.

Dr. J. W. Scott Macfie : --20 Culicidae, 7 Tabanidae, 93 *Glossina*, 2 *Cordylobia*, 127 other Diptera, a number of Dipterous larvae and pupae, 32 Coleoptera, 8 larvae and 2 pupae, 2 Hymenoptera, 7 Lepidoptera, 3 Rhynchota, and 33 Trombidiidae ; from the Gold Coast.

Mr. G. A. Mavromoustakis :—85 Lepidoptera : from Cyprus.

Mr. David Miller :—1 Weevil ; from New Zealand.

Mr. N. C. E. Miller :—984 Coleoptera and 121 Orthoptera ; from Tanganyika Territory.

Prof. A. Mokrzecki :—2 Diptera ; from Poland.

Dr. Carlos Moreira :—2 Weevils ; from Brazil.

Mr. N. A. Murray :—121 Coleoptera, 2 Hymenoptera, 7 Rhynchota, and 5 Orthoptera ; from Western Australia.

Mr. W. H. Patterson :—7 species of Coccidae ; from the Gold Coast.

Mr. A. W. J. Pomeroy, Government Entomologist :—28 Diptera and 10 pupa cases, 37 Lepidoptera, and 3 Rhynchota ; from Southern Nigeria.

Mr. Y. Ramachandra Rao, Government Entomologist :—1 Carabid beetle and 1 Phasmid ; from South India.

Mr. A. H. Ritchie :—498 Coleoptera, 45 Hymenoptera, and 73 Rhynchota from Tanganyika Territory.

Section of Entomology, Khartoum :—20 Coleoptera ; from the Sudan.

Mr. H. W. Simmonds, Government Entomologist :—2 *Tabanus*, 26 other Diptera, 49 Coleoptera, 13 Hymenoptera, 50 Lepidoptera, 2 species of Coccidae, 37 other Rhynchota, and 2 Planipennia ; from Fiji.

Mr. E. R. Speyer :—4 Dipterous larvae, 2 Coleopterous larvae, 5 Thrips, and 50 Collembola ; from Cheshunt, Herts.

Mr. R. Swainson-Hall :—1 *Glossina*, 8 Coleoptera, and 1 Pentatomid bug ; from British Cameroons.

Mr. R. J. Tillyard :—1 species of Aphidae ; from New Zealand.

Mr. Tunstall :—3 Hymenoptera and an example of borings ; from Assam.

Mr. F. W. Urich :—9 Chalcid parasites of Thrips, 10 Thrips ; from Trinidad.

Mr. R. Veitch :—7 Diptera, 12 Coleoptera, 33 Parasitic Hymenoptera, 40 other Hymenoptera, 112 Lepidoptera, 1 species of Aphidae, 3 species of Coccidae, 35 other Rhynchota ; from Fiji.

Wellcome Bureau of Scientific Research :—328 Culicidae, 24 other Diptera, and 4 Coleoptera ; from Tanganyika Territory.

Mr. G. N. Wolcott :—14 Coleoptera, 2 Lepidoptera, and 7 Rhynchota ; from Porto Rica.

Mr. T. L. Wurth :—36 Coleoptera ; from Java.

# GENERAL INDEX.

# INDEX TO NAMES OF PERSONS.

Dates of Publication in Parts.

Part 1: 31st May 1922.
Part 2: 31st August 1922.
Part 3: 31st January 1923.
Part 4: 9th May 1923.